Section II
MASTER PLAN

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MASTER PLAN FORMULATION

In Section I, Basin Evaluation, the results of studies of hydrology, hydraulics, water quality, and physical characteristics of Beal Slough basin were presented and discussed. Based on what was learned from those analyses a proposed master plan for stormwater management within the Basin has been formulated. The Beal Slough Master Plan is intended to provide a sound basis for making improvements within the watershed for effective management of stormwater and protection of urbanized/developed areas from flooding. In identifying the proposed plan, three concept management plans were developed and evaluated. The three plans were presented in the September 1998 Concept Management Plan Alternatives Beal Slough Basin Planning Report draft. Each concept plan incorporated the following stormwater management components:

- application of reasonable Best Management Practices to trap sediment and enhance stormwater quality
- bioengineering approaches to provide channel stability
- use of vegetative buffer strips along streams and channels
- infrastructure capacity improvements
- identification of adequate major storm flow paths

Two of the concept plans also included components to store storm runoff to reduce downstream peak rates of flow and flooding. The three concept plan alternatives were evaluated in relation to peak flow reduction provided, implementability in an almost fully-urbanized watershed, and associated costs. As the three concept plans were considered and evaluated by project sponsors, it was expected that prioritization of components and some blending of concept plans would occur and be reflected in the final Plan for the basin.

The proposed Stormwater Master Plan is a composite of most of the elements of the three concept plan alternatives. It is intended to be a viable, long-term reference for prioritizing improvement projects within the basin as funding mechanisms are identified and implemented.

ISSUES ADDRESSED

As identified in Section I Basin Evaluation, key issues to be addressed in the basin are related to changing hydrologic conditions which result primarily from conversion of land to urbanized uses. Increased runoff from on-going urbanization contributes substantially to a number of stormwater management issues:

- Flooding becomes more frequent and severe.
- More property along flood paths becomes subject to flooding.
- Stormwater facilities become overloaded and need to be prematurely replaced or augmented with additional capacity.
- Higher flow velocities and longer periods of flow cause erosion and channel instability.

- Erosion results in pollution, deposition of sediment, undermining of utilities and infrastructure, and loss of natural biological diversity.

PROPOSED MASTER PLAN

There are many management practices from which to choose in formulating a stormwater master plan for a specific basin. Selection of plan components is based on economic considerations as well as evaluation of stream reaches; bridge and culvert capacity needs; streambed and channel bank stability; riparian vegetation; tributary confluence locations; maintenance access needs; and other basin characteristics.

The Beal Slough Master Plan includes the following stormwater management components: best management practices to improve stormwater quality; bioengineering approaches to provide channel stability while improving stormwater quality; stormwater storage and major storm drain infrastructure improvements to reduce flooding and increase the capacity of the channel, bridges, and conduits that convey stormwater in the Beal Slough Basin. The major capital cost components of the Plan are shown on Figure MP-1 at the end of this Section II. The Plan is described in greater detail on the master plan (MP), plan component (PC), floodplain (FP), and concept detail (CD) figures which follow Figure MP-1.

Utilizing Best Management Practices

There are a number of Best Management Practices (BMPs) and bioengineering approaches that can improve stormwater quality, provide channel stability, and help trap sediment in the Beal Slough Basin, if implemented. Both structural and nonstructural BMPs can be utilized beneficially.

Examples of structural and non-structural BMPs that are applicable for the basin include:

- constructed wetlands
- the use of vegetative buffer strips along streams and channels
- development of a management plan to control pollutants (this is a requirement for the City's Municipal Separate Storm Sewer System permit from the Department of Environmental Quality)
- City of Lincoln/LPSNRD/NPDES Construction Site Permit compliance
- conveyance improvements which maximize use of vegetative stabilization
- multipurpose retention/detention facilities
- maximizing open space in developments
- education of reviewers, developers, engineers, contractors and inspectors

Stormwater Quality Management

Improving storm water quality in Beal Slough will require a comprehensive approach to address multiple sources of pollutants. Runoff from urbanized areas can be directed to constructed wetlands designed to remove nutrients, dissolved pollutants, oil and grease. Improved design, installation and enforcement of construction site erosion and sediment control plans will reduce the amount of sediment and pollution leaving the sites and entering the stream or downstream properties. Grade checks, bioengineering, and peak flow rate reduction will improve stream bed and bank stability to reduce erosion, suspended solids and downstream deposition of sediment.

Water Quality Wetlands

Figure MP-1 indicates nine proposed water quality wetland locations. The locations are more specifically indicated on the subsequent plan component (PC) and concept detail (CD) drawings. Three locations are proposed as forebays to improve water quality and reduce maintenance costs for existing stormwater retention ponds. Consideration should be given to establishment of those wetland areas in conjunction with future maintenance operations for the ponds. The other six sites are at locations along Beal Slough where channel or streambank improvements are proposed or where tributaries enter the main channel. Consideration should be given to establishment of those wetland areas in conjunction with channel or streambank improvements at or in the vicinity of these locations. Establishment of water quality wetlands would also occur along with construction of new stormwater storage facilities. Incorporation of water quality wetlands into smaller stormwater storage facilities constructed for specific subdivisions or developments, in accordance with the City of Lincoln Drainage Criteria Manual, should be encouraged.

Stormwater quality wetlands would improve the quality of subbasin stormwater prior to discharge into the mainstem or tributaries through biological uptake of nutrients, bio-degradation of chemicals, and physical filtering of sediment. The facilities should be designed to provide 24- to 48 -hour detention time for the first 1/4 to 1/2 watershed-inch of runoff from each storm event. Many wetland plants volunteer where soil and hydrology provide favorable conditions, however planting specific vegetation that is better suited to removal of nutrients will improve the removal efficiency of wetlands.

Plant species suggested for inclusion in Beal Slough wetlands are listed below. Most of these species have relatively high value for wildlife, providing food, habitat, or both. Some, as indicated by the asterisk (*), are particularly useful for removing nutrients from water.

For open water wetlands (permanent pools, water relatively deep):

- White waterlily (*Nymphaea tuberosa*) – Plant in up to 5 feet of water
- American lotus (*Nelumbo lutea*) – Up to 2 feet of water
- Sago pondweed (*Potamogeton pectinatus*) – Needs a permanent pool of water

Floating duckweed (*Lemna* spp.) are likely to volunteer.

For emergent wetlands (with permanent pools, water relatively shallow):

- Arrowhead (*Sagittaria latifolia* or equivalent species) – Plant in up to 2 feet of water
- Water Plantain (*Alisma plantago-aquatica* or *A. subcordatum*) – Up to 1 foot of water
- Giant Bur-reed (*Sparganium eurycarpum*) – Up to 1.5 feet of water

For emergent wetlands (very shallow water or seasonally flooded):

- *Three-square bulrush (*Scirpus americanus*) – Plant in <3 inches, will spread to deeper
- *Alkali bulrush (*Scirpus paludosus*) – Same
- *Hardstem bulrush (*Scirpus acutus*) – Same
- *Softstem bulrush (*Scirpus validus*) – Same
- Soft rush (*Juncus effusus*) – Plant in 2-3 inches or less
- Torrey's rush (*Juncus torreyi*) – Plant in wet places

Cattail (*Typha latifolia* and *T. angustifolia*) and smartweed (*Polygonum* sp.) will volunteer here, and do not need to be planted.

For emergent wetlands (seasonal or temporary flooding):

- Swamp milkweed (*Asclepias incarnatum*)
- Nodding beggar-tick (*Bidens cernua*)
- Sedge (*Carex* spp.)
- Rice cutgrass (*Leersia oryzoides*)
- Prairie cordgrass (*Spartina pectinata*)

For forested wetlands (temporary flooding):

- Willows (*Salix* spp.)
- Green ash (*Fraxinus pennsylvanica*)
- Cottonwood (*Populus deltoides*)
- Box-elder (*Acer negundo*)
- Red-osier dogwood (*Cornus stolonifera*)
- American elderberry (*Sambucus canadensis*)

Peach-leaf willow (*S. amygdaloides*) and cottonwood are likely to occur as volunteers.

Construction Site Erosion and Pollution Control

Water quality improvement will occur in Beal Slough basin with improved adherence to existing federal, state, and local regulations regarding construction site erosion pollution control. Accelerated education by the City and LPSNRD of designers, contractors, and builders about compliance requirements and techniques will be the primary approach to this issue in Beal Slough. Cooperative administration and enforcement by the City and LPSNRD will also be needed. Ordinance modifications, criteria, and standards adopted by the City effective 23 March 2000 should accomplish implementation of effective construction site BMP's.

Streambed and Channel Bank Erosion Control

Water quality improvement through reduction of channel erosion will be accomplished through a combination of stormwater management practices to control or accommodate the future hydrologic and hydraulic characteristics of the basin. Streambed and channel bank erosion will be managed by a number of the storage and conveyance system capital improvement components indicated on Figure MP-1. They are described in more detail in later discussions of this section.

Establishment and Preservation of Riparian Vegetation Buffer Zones

Space should be provided and preserved for a riparian vegetation buffer zone along each side of the Beal Slough mainstem and tributary channel corridors. Sediment and pollutants will be filtered from stormwater as it flows through the vegetation, improving the quality of water flowing in the channels. In addition to water quality benefits, vegetative buffer zones provide environmental diversity within urbanized areas by preserving natural habitat for wildlife species.

Each buffer zone should be a minimum of 30 feet in width. Where possible, they should be 100 feet or more in width. Buffer zones which are wider than the minimum will provide greater water quality benefits, more space for flow and storage of stormwater, and also provide opportunities for future multi-purpose use of channel corridors.

In areas of the basin where urbanization is still in progress, buffer zones should be established through the development process in accordance with the City of Lincoln Drainage Criteria Manual. In currently urbanized areas care should be taken to avoid unnecessary loss of existing riparian vegetation. Efforts should be made to identify and act on future opportunities to establish buffer zones where none exist today. Such opportunities could arise during stormwater management or utility infrastructure projects or, perhaps, during future redevelopment projects on some tracts of land within the basin.

Stormwater Quality Educational Programs

In addition to the physical features which need to be enhanced, preserved, or augmented to improve water quality in Beal Slough, efforts and programs to educate citizen and business groups need to be continued and improved. Proper use and disposal of lawn, commercial, and household chemical products is obviously very important. Proper disposal of trash, lawn, and other waste materials is also important.

Laws and regulations addressing these issues are in place. Improved compliance can best be accomplished through further education and improved public understanding of proper methods and the environmental reasons for using them. Several agencies currently promote public education regarding these issues. The jointly sponsored City and LPSNRD program, specifically targeted towards furthering awareness of the importance of these issues for Beal Slough and downstream natural resources, will be beneficial for the basin and the entire City.

Stormwater Quantity Management

Based on the proposed Master Plan facilities being completed and operational, Tables MP-1 and MP-2 give a listing of 2-, 10-, and 100-year frequency rates of flow at several locations in the basin. For comparison,

Table I-10 in Section I Basin Evaluation, indicates corresponding rates of flow for 1997 conditions and FIS (1978) conditions in the basin. Appendix A includes 2-, 10-, and 100-year frequency rates of flow at the lower end of each subbasin in the Master Plan hydrology model. The water surface profiles and peak flow rates for 1997 conditions should be referred to until the Master Plan components and target flow rates are realized. Future developments or other changes within the basin should be analyzed and designed so the aggregate of changes within any subbasin does not result in increased rates of runoff from the subbasin.

Table MP-1
Target Peak Flow Rates at Selected Locations on the Mainstem

Location	Master Plan Element Name	Cumul. Area (sm)	2-Year Event	10-Year Event	50-Year Event	100-Year Event
			cfs	cfs	cfs	cfs
84th Street	84th	0.28	260	540	780	880
70th Street	A	1.76	70	110	110	110
BNSFRR	BNSF64	3.48	600	1400	2000	2400
Pine Lake Road	PineBx	4.03	680	1500	2300	2600
56th Street	56thBr	5.13	870	2000	2900	3400
Old Cheney Road	55OldC	5.30	970	2300	3300	3900
BNSF/Hwy2 Bridge	BNRR	5.48	970	2300	3300	3900
48th Street	48thBr	6.05	1200	2700	4100	4800
40th Street	40thSt	6.93	230	890	2500	2500
Supplemental Box Culvert	40SUPL	N/A	1100	2300	2200	3100*
Hwy2/BNSF Bridge	BNRR38	6.93	400	1200	2900	2900
Beal Slough	R31	8.12	1900	4000	4300	4900
27th Street	27thSt	11.35	3000	6400	8000	8700
Southwood Drive	Southw	11.69	3000	6400	8100	9000
Highway 77(14th St.)	Hwy77	12.96	3200	6900	9000	10000
Penitentiary Bridges	Pen RR	13.09	3200	6900	9000	10000
Pioneers/BNSF Br.	Pionee	13.38	3200	6900	9100	10100
Mouth at Salt Creek	R61	13.51	3200	6900	8700	9600

*Under 1997 and FIS (1978) conditions, as indicated in Table 1-10 of Section I Basin Evaluation, flow through this Master Plan supplemental culvert would pass through the 40th Street and Highway 2/BNSF structures. For purposed of comparison with Table 1-10, add 3100 cfs to the 40th Street and Highway 2/BNSF structure 100-year event rates of flow in this table.

Stormwater Storage Improvements

Flooding may be reduced by decreasing the rates of flow in the stormwater conveyance system. Rates of flow can be reduced by temporarily storing excess water in planned retention or detention areas until the conveyance system has drained down sufficiently to handle it. Storage facilities may be off-channel or on-channel. On-channel facilities intercept stream flows directly. The entire volume of storm runoff passes through the facility. Off-channel facilities provide temporary storage of flood waters diverted from the stream and only a relatively small portion of the storm runoff volume passes through the facility.

Table MP-2
Target Peak Flow Rates at Selected Locations on Tributaries

Location	Master Plan Element Name	Cumul. Area (sm)	2-Year Event	10-Year Event	50-year Event	100-Year Event
			cfs	cfs	cfs	cfs
Yankee Hill Rd	Yankee	0.77	350	800	1100	1300
70th Street	N16	1.13	420	960	1400	1600
Pine Lake Road	N17	1.23	470	1100	1600	1900
Highway 2	22Box	0.13	50	100	110	120
Highway 2	21Box	0.17	60	60	70	70
Pine Lake Road	Pinels	0.26	150	180	300	370
Pine Lake Road	Pineln	0.46	110	270	450	540
Browning Street	Browng	0.87	80	270	450	550
Pine Lake Road	EagleC	0.23	200	320	390	430
Fox Hollow Drive	Fhollo	0.42	370	690	870	980
Cripple Creek Drive	CrpCr	0.49	410	770	1000	1100
40th Street	40th	0.77	560	1100	1500	1700
34th Street	Will34	0.96	670	1300	1800	2100
Jane Lane	JaneLn	2.29	870	1800	2600	3000
Old Cheney Road	OldChn	2.34	870	1800	2600	3000
Sequoia Drive	Sequoi	2.63	990	2100	3000	3500
Tierra Drive	Tierra	2.72	1000	2100	3100	3600

Off-Channel Storage - The Master Plan includes one off-channel regional storage facility southwest of 40th Street and Highway 2 as shown on Figures SG3-PC and SG3-CD2. This proposed facility and other locations were investigated by review of aerial photography and topographic contour mapping. The locations were field checked to evaluate availability. Sites which appeared to have potential were evaluated for effectiveness using the Master Plan computer models. The modeling analysis identified the proposed site as the most effective of the off-channel storage locations investigated.

Off-channel storage facilities, also referred to as side-channel detention structures, may be used to reduce peak flow rates by storing the portion of a storm hydrograph that exceeds a given flow rate. Stormwater is diverted by a side-channel spillway into the storage facility. The stormwater is stored until the water level recedes in the conveyance channel, allowing gravity drainage of the structure. Off-channel storage facilities can also be used to improve stormwater quality by diverting and storing the more polluted “first flush” of stormwater runoff.

Storage volume requirements for off-channel facilities are typically less than those for on-channel facilities because they store only the portion of hydrograph which spills over into the off-channel storage facilities after the conveyance system capacity has been exceeded. Peak flow reduction capability of off-channel facilities is reduced if all or part of the storage volume has already been filled when the flood peak arrives. This may happen when a storm hydrograph has an unusual shape. Peak flow reduction capability for on-channel facilities is not as dependant on the shape of the storm hydrograph because they are hydraulically designed to handle the entire hydrograph rather than only a portion of it.

As shown on Figures SG3-CD1 and SG3-CD2, the proposed off-channel facility would be constructed in conjunction with channel improvements between Highway 2 and 27th Street. The combination of improvements would address and reduce the flood hazard to properties along Beal Slough upstream of its confluence with the Tierra Branch Tributary. It also would reduce peak rates of flow experienced at 27th Street from major storm events.

On-Channel Storage - The Master Plan includes target peak flow rates for the 2-, 10- and 100-year storm events that could be achieved by construction of stormwater storage facilities in the subbasins delineated by shading in Figure MP-1. Due to urban locations, each facility would be designed and constructed as a class 'c', high hazard dam. Seven subareas in the upper portion of the basin are delineated on Figure MP-1. Implementation of regional storage within subareas A, D, E, and G could substantially contribute to reduction of 1997 100-year flow rates towards the targeted Master Plan 100-year flow rates as shown on Figure MP-2. The subbasins are in the upper portions of the watershed. The target peak flow rates could reduce the uncontrolled 100-year flow rate on Beal Slough by 70% at the Pine Lake tributary confluence by about 50% from there to 56th Street and by 25% from 56th Street to 40th Street. The target peak flow rates would have little effect on peak rates of flow downstream of 48th Street.

Reduction in peak flow rates for the 2-year, and perhaps more frequent, peak flow rates would be beneficial for stream stability and water quality.

Implementation of regional storage within those subareas could substantially contribute to reduction of 1997 100-year flow rates towards the targeted Master Plan 100-year flow rates as shown on Figure ES-5. For example, Table MP-3 shows the reduction in downstream uncontrolled 2-year frequency flows that proposed target peak flow rates from the upper most subbasins could accomplish.

Table MP-3
Subarea 1997 and Target Peak Flow Rates for 2-, 10-, 50-, and 100-year Storms

	2-year		10-year		50-year		100-year	
Subarea	1997	Target	1997	Target	1997	Target	1997	Target
A	390	200	930	470	1390	680	1610	790
D and E	540	65	1240	106	2010	108	2360	109
G	400	220	970	520	1450	750	1710	870

Table MP-4
2-year Peak Flow Rate Comparison of 1997 Rates and Target Rates

Reach	1997 2-Year Rate of Flow - cfs	2-Year Target Rate of Flow - cfs	% Reduction
Downstream of 70th Street	541	56	90
Upstream of BNSF RR (6300E)	617	173	72
Downstream of BNSF RR (6300E)	929	605	35
Upstream of Pine Lake Road (6200E)	919	580	36
Downstream of Pine Lake Road (6200E)	985	649	34
Upstream of 56th Street	1070	722	33
Upstream of 56th Street	1172	845	28
56th St. to Old Cheney Road	1182	854	28
Old Cheney Road to Hwy. 2 (5200E)	1317	968	26
Hwy. 2 (5200E) to 48th Street	1537	1159	25
Downstream of 48th Street	1636	1327	19
Upstream of 49th Street	1703	1321	22

Based on published guidelines and observed channel conditions, the 2-year frequency flow rate is the channel-forming flow rate for Beal Slough. The channel-forming flow is the flow rate that determines the channel depth and width. In undeveloped areas natural channels would be bank-full under channel-forming flow conditions. In urbanized areas the channel cross-section is typically enlarged beyond the channel-forming flow capacity by erosion due to higher flow velocity. Maintaining or reducing the 2-year frequency flow can be key to cost effective maintenance of channel stability. As unstable channels grow from erosion, adjacent improvements such as bikepaths, utilities and buildings can be undermined.

Stormwater Conveyance System Improvements

For purposes of the Master Plan, the basin conveyance system consists of the Beal Slough mainstem channel and flood plain; tributary channels and flood plains from the mainstem to the lower end of the uppermost sub-basin on each tributary; and bridges or box culverts which cross the mainstem or tributaries. Conveyance culverts, conduits, channels, and related facilities within the subbasins are considered as minor system components and are not specifically addressed by the Master Plan. The information in Appendix A gives peak runoff rates for various frequency storm events at the lower end of each sub-basin. Development and design of minor system components within the subbasins should be done in a manner that, in aggregate, will not increase the Master Plan outflow rates for each subbasin.

As indicated on Figure MP-1, the proposed Master Plan includes number of major conveyance system capital improvements. The improvements are indicated in more detail on the master plan (MP), plan component (PC), and concept detail (CD) figures which follow Figure MP-1. In general, conveyance system improvement components are proposed where system restrictions or deficiencies cause substantial flood hazard to buildings or infrastructure and where severe channel instability exists.

There are a number of areas along the Beal Slough channel between 56th Street and its mouth at Salt Creek where the streambed and/or banks are unstable. The proposed Master Plan includes improvements to address critical locations where instability threatens, or is likely to threaten, the stability of buildings or other infrastructure.

Improvements are also included to address significant conveyance deficiencies in the vicinities of Highway 77 (14th Street), Southwood Drive, 27th Street, 40th Street, 56th Street, Pine Lake Road, and 84th Street. The deficiencies were identified using the Master Plan hydraulic model and basin topographic mapping to determine locations where improvement in conveyance capacity could significantly reduce existing hazard of flood damage.

Channels - Channel improvements have two basic purposes: to provide stability against streambed and bank erosion, and to provide adequate capacity. The proposed Master Plan includes channel improvements targeted towards both purposes and improvements targeted primarily towards channel stability. The included improvements were selected, on a priority basis, from a myriad of possible channel improvements within the basin.

Figure MP-1 shows levee improvements along the mainstem of Beal Slough, both to the west and east of Highway 77 (14th Street), which address both capacity and stability deficiencies. The channel improvements shown west of 27th Street and to the north of Beal Slough, east of 27th Street, would also address both purposes. The channel improvements indicated to the south of Beal Slough, between 27th and 40th Streets, are intended to address localized, severe erosion and stability problems in that reach of the stream. The training dikes east of 40th Street and south of Pine Lake Road primarily address capacity deficiencies, but also need to be designed for stability. The channel improvements indicated on Figure MP-1, west of 56th Street and west of 84th Street, also address both the capacity and stability purposes.

Capacity improvement generally includes excavation to deepen and/or widen the channel at constriction locations. It may also include channel re-construction along a new alignment, construction of a supplemental by-pass channel, or construction of embankment for levees or training dikes where one or both channel banks are too low to contain an adequate rate of flow.

Where the channel is becoming too deep and wide due to active erosion, streambed degradation can be arrested by constructing grade check structures or by hard surfacing the channel bottom. To maintain more natural channel characteristics, and to manage costs, the use of grade check structures is proposed for Beal Slough rather than continuous hard surfacing of the channel bottom. Effective grade check structures currently exist where there are roadway culverts with cut-off walls and where other forms of cross-channel stabilization are maintained by private companies or public agencies to protect utilities, railroads, or roadways.

Natural earth channel flowlines will erode to a stable grade upstream and downstream of each grade check structure. If grade check structure depth and spacing does not anticipate degradation of the stream to a stable slope, grade check structures may be undercut and become ineffective. The general soil and hydrologic characteristics of the basin indicate a stable earth steambed grade in Beal Slough will generally be 0.14% or less.

At each location where improvements are made to address channel capacity or stability problems, the need for incorporation of a grade check structure should be considered. A grade check structure should be included in the improvement if there is a probability of further streambed degradation upstream or downstream of the improvement location. A typical grade check structure would provide for about 3 feet of vertical elevational drop in the streambed and include upstream and downstream aprons which are sufficiently stabilized to withstand the changes in hydraulic velocity and energy which result from the drop.

In Beal Slough, most unstable channel banks result from streambed degradation, erosive scour of the toe of the bank, or concentrated drainage of water through or over the bank. Channel bank stabilization components of the Master Plan are based primarily on use of bio- technical rather than traditional measures. Combinations of bio-technical and traditional “hard” stabilization practices may be required where unusual conditions or streambed degradation needs to be addressed.

Potential in-stream, bio-technical channel stabilization practices include:

- anchoring of felled trees
- constructing wing deflectors
- bank shaping and re-vegetation
- branch packing in scoured areas
- planting live stakes
- live fascines to shorten effective slope length
- live tree, log, rootwad, and boulder revetments
- channel restoration, including re-connection or re-construction of stream meanders

Bridges and Box Culverts - Effective capacity of existing bridges and box culverts was determined by the elevation of adjacent building low openings, or the roadway overtopping elevation, depending on which is lower. The controlling elevation and need for improvement were evaluated where existing capacity would be frequently exceeded. Where bridge/box culvert replacements, or augmentations are included in Master Plan, improvements were identified that would provide a minimum 100-year capacity for highways and railroads and

a minimum 50-year capacity for other roadways.

Due primarily to the substantial increase in peak flow rates in the lower reaches of Beal Slough, the Highway 77 (14th Street) bridge only has capacity to pass approximately a 8-year frequency storm runoff without the highway being overtopped. The Nebraska Department of Roads (NDOR) owns the bridge and currently has no plans to replace it. Structurally, the bridge is in good condition and has a structural sufficiency rating of 88 out of 100. NDOR staff has suggested that, because the sufficiency rating is so high, the bridge will likely not be placed on a replacement planning list for 15 years or more. Although replacement of the bridge is included in the Master Plan, the existing bridge will likely remain in service until State and Federal funding is available to upgrade Highway 77 in the future. The system of levees upstream and downstream of Highway 77, as shown on Figures SG1-PC, SG1-CD, and SG2-PC, would need to be scheduled to coordinate with improvement of the Highway 77 bridge.

The Southwood Drive box culvert has capacity to pass runoff from only a 14-year storm event. During intense storm events, overflow of Southwood Drive causes hazards and delays for traffic, but not substantial property damage hazard. To comply with City design standards the box culvert should have a 50-year capacity.

The 40th Street Box culvert has capacity to pass runoff from approximately a 7-year storm. When more intense events occur, a residential area east of 40th Street and north of Beal Slough is prone to flooding. During a 100-year event, 45 houses would be subject to flooding. The oblique alignment of Highway 2, downstream of 40th Street, limits the effectiveness of the existing box culvert and the potential to increase the capacity through 40th Street. Figures SG4-PC and SG4-CD1 show a potential supplemental box culvert concept which would by-pass excess flow to the south side of Highway 2 through the intersection of 40th Street and Highway. The supplemental box culvert, in combination with a training dike along the north bank of Beal Slough and a storm drainage conduit improvement along Gertie Avenue, would relieve the flood hazard to the residential area.

MINOR SYSTEM IMPROVEMENTS

Improvements to the minor drainage (storm sewer) system at some locations can redirect storm flow discharges into the mainstem or tributaries in a non-damaging manner rather than running through homes and businesses. For example, improvement of the minor system at Gertie Avenue and Ginny Avenue is necessary in conjunction with the proposed training dike along Beal Slough upstream of 40th Street. The proposed conduit (84 -inch diameter RCP) will handle up to one-half of the 100-year runoff from the neighborhood. Grading an overland swale from Ginny Avenue to Beal Slough will handle the flow in excess of pipe capacity. These improvements were included in the Master Plan because they are necessary for proper operation of the other Master Plan Components at 40th Street.

Several other deficiencies in the existing storm drain conduit system were identified during study of the basin. Although correction of all those deficiencies is not directly a part of the Master Plan for the major system, a summary of the minor system evaluation from Appendix A of the Interim Basin Study report is included as Appendix E.

OPINIONS OF PROBABLE COST

Figure MP-2 lists preliminary opinions of probable cost for major capital cost components of the Master Plan. The cost opinions were prepared based on cost information from recent comparative projects in the vicinity of Lincoln. The comparative cost information was indexed to be representative for 1999 conditions and applied to preliminary quantities of cost items determined from concept level designs for the Master Plan components. Allowances were included for construction, land rights, design, construction observation, relocation of known utility conflicts, and contingencies. Where the construction schedule of a Master Plan component will need to be coordinated with future improvement to another infrastructure system, i.e. the Highway 77 bridge, costs to modify the infrastructure system to accommodate the Master Plan component were not included.

STORMWATER MANAGEMENT PLAN IMPLEMENTATION

Successful implementation of the master plan will require a number of elements: cooperation of governmental units and citizens; an adequate funding program; an aggressive capital improvement program; educational programs for the public; and effective operation and maintenance. More clear definition of each of these elements will be possible as interlocal agreements, policy decisions, ordinance revisions, and economic evaluations move ahead.

Consensus and Definition of Responsibilities

An important initial step in implementation is reaching agreement among City, NRD, and County officials about priorities for Plan implementation. Decisions need to be jointly arrived at regarding which portions of the Plan will be pursued first and what the responsibilities of each agency will be. A key issue will be determination of a workable blend of funding mechanisms.

Funding Options

The Beal Slough Stormwater Master Plan includes a program of potential capital improvements for the basin which would require over $15 million in funding over a period of several years. Figures MP-2, MP-3, MP-4, and MP-5 outline 3 proposed tiers of prioritization with $4.3 million of proposed first priority improvements. Funding of such stormwater management facilities in Lincoln has historically been done in one of the following ways:

- Bond issue financing of City Storm Sewer projects.
- General revenue appropriation.
- Cooperative cost sharing by the City and NRD for projects of joint interest and responsibility.
- NRD funding of channel improvements.
- City use of Federal Highway Administration and Nebraska Department of Roads assistance for bridges and box culverts.
- Private funding of stormwater facilities required for the land subdivision and development process.

To begin effective implementation of the Beal Slough Plans City, NRD, and County officials will need to determine what portions of the Plan to fund, when to fund them, and what portion(s) each governmental unit may assume financial responsibility for, and how the dollars will be obtained.

Innovative methods of financing may need to be identified and developed. For example, a future stormwater storage facility in one of the target subbasins may be an opportunity for public and private cost sharing. The site may have opportunities which fit with the interests of the City and NRD. Partnering of public and private resources would be based on the potential relative benefit each sector would receive.

If the Beal Slough Plan is to be fully implemented, it is likely that non-traditional funding programs will be necessary. Public/private partnerships, land development impact fees, basin stormwater system assessments, and City-wide stormwater utility revenue fees are some possibilities. Some options may require modification of City ordinances and state statutes for their potential to be realized.

Administration, Operation, and Maintenance

During and after implementation of a Plan for stormwater management of Beal Slough Basin, cost-effective administration and maintenance of stormwater systems and programs will be needed for reliable operation. Cooperative, pro-active planning that recognizes and accommodates the division of responsibilities between the City, NRD, County, and private entities will be needed as well as an adequate level of funding. The chain of authority and responsibility for the several aspects of the stormwater management system will likely need to be defined and provided for within an inter-local agreement.

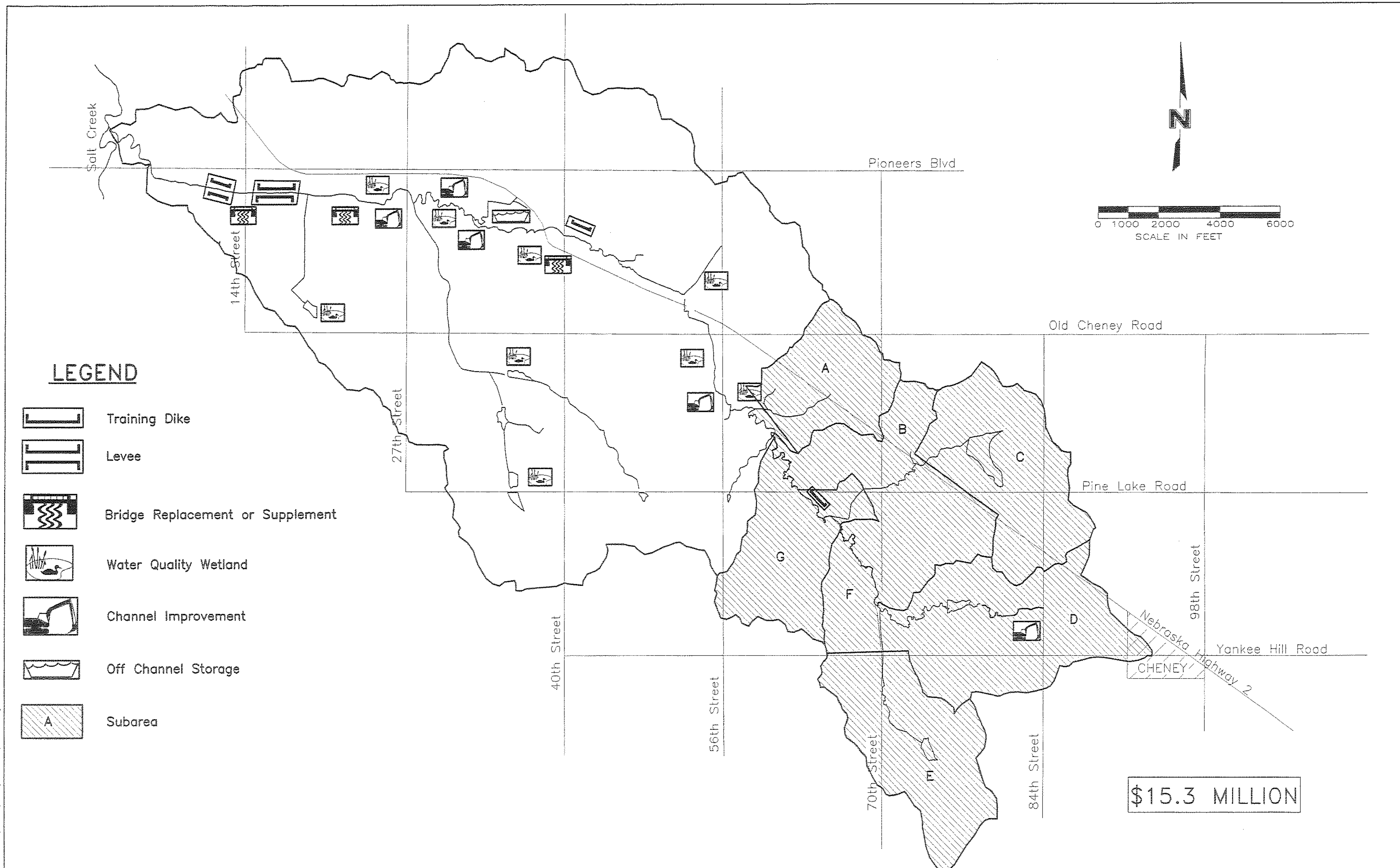
Changes in policies, legal structure, and thinking may all be necessary to move the Plan ahead effectively. A key part of stormwater quality management in the basin will be public awareness and cooperation regarding pollution prevention and management. Development of community cooperation in implementing BMP's to manage stormwater quality will require development of educational and awareness programs to assist citizens and businesses in responsibly complying with applicable regulations. These programs will need to be on-going to maintain an appropriate level of understanding and cooperation as leaders of businesses, homeowners associations, and other groups change over time.

Periodic inspection and maintenance of stormwater system facilities is necessary to assure reliable operation and to manage the cost of repairs. Minor maintenance problems can turn into major repair projects if they are not discovered and attended to. The City and NRD need to lead efforts to identify and address maintenance and operation issues whether the responsibility to perform a specific maintenance function is public or private. If facilities don't operate properly when needed, private and community costs are incurred.

A sound channel conveyance system requires adequate, perpetual space along mainstem and tributary channel corridors. Adequate space is needed within each channel corridor for stormwater system administration access, for maintenance operations, for preservation or re-establishment of riparian vegetation buffer zones on each side of the channel, and for passage of runoff from a 100-year storm with minimal damage. Where development is still in progress, dedicated channel corridors need to be provided in accordance with the requirements of the City of Lincoln Drainage Criteria Manual. In currently urbanized areas, efforts should be made to obtain sufficient channel corridor rights for future administrative and maintenance access, and for passage of stormwater runoff from storms up to and including the 100-year event. Future needs for public trail and utility systems along channel corridors should also be considered and provided for.

Adequate, perpetual space is also necessary at stormwater storage facilities whether they are publicly or privately owned and maintained. The primary public interest is that the planned storage volume is available for safe flood management and water quality enhancement when needed. Maintenance of permanent pool volume and open water area for aesthetic and other multi-use purposed, although important, is secondary. Through cooperation, pro-active planning, and use of sound management practices maintenance of stormwater management and other multi-purpose functions can be accomplished.

As development and other changes continue to occur within Beal Slough Basin, the computer models and information developed during this master planning effort should be used as management tools to identify and evaluate options which will allow change to be accomplished in a manner that is consistent with sound basin stormwater management practices and the goals of the community.



DRAWN BY: JJM
DATE: JUNE 1999
REVISIONS:

BEAL SLOUGH MASTER PLAN

LINCOLN, NEBRASKA

MASTER PLAN
MAJOR CAPITAL COST COMPONENTS

FIGURE MP-1

Table MP-5

Preliminary Opinion of Approximate Cost for Major Capital Components[1]

Stream Segment	Component Description	Priority Tier One	Priority Tier Two	Priority Tier Three	
1 & 2	Tie-back levees from BNSFRR near the penitentiary to the railroad spur downstream of Southwood Drive			$2,300,000	Develops additional capacity of BNSFRR bridge near the penitentiary and provides 100-year flood protection of the State Penitentiary. Provides 100-year flood protection of the Nash Finch Company warehouse facility, a commercial storage business and the LES substation. Levee construction must be phased to coordinate with Highway 77 bridge replacement.
2	Replace NDOR Highway 77 bridge			$1,100,000	Provides 100-year capacity without overtopping Highway 77. Bridge replacement should be to coordinate with levee construction.
2	Replace Southwood Drive structure			$600,000	Provides 50-year capacity for a collector street
2	Channel improvement below 27th Street Culvert outlet	$500,000			Increases box culvert performance to near 50-year level and provides stable streambed and channel banks
3	Off-channel storage facility and new channel	$1,600,000			Reduces peak flow rates using storage near the Tierra Branch confluence and reroutes flood flows to a stable channel.
3	Overflow channel and channel improvement above 27th Street Culvert	$200,000			Improves channel capacity and reduces water surface profiles near the Tierra Branch confluence.
4	Supplemental culvert under 40th Street and Highway 2, training dike, enlargement of bridge openings at Highway 2 and BNSFRR	$1,600,000			Eliminates mainstem induced flooding of 42 residences north of the channel during 100-year flood. Minor system improvements on Gertie Avenue reduce local flooding ($600,000 minor system improvements included).
7	Training dike at BNSFRR upstream of Pine Lake Road		$300,000		Eliminates bypass that causes frequent flooding of Pine Lake Road and enhances bridge performance.
Multiple	Upper Beal Slough Storage Facilities	$1,000,000	$1,500,000	$1,500,000	Reduces peak flow rates using on-channel storage, working in combination with other facilities to improve capacities of downstream bridges. Provides potential for multiuse benefits.
All	Streambed and streambank stability measures and channel improvements	$1,100,000	$2,000,000		Bioengineering measures including instream practices, streambank treatment, and channel improvements at multiple locations along Beal Slough.
	$15,300,000	$6,000,000	$3,800,000	$5,500,000	

[1] Based on 1999 costs

Master Plan Improvement in Peak Flow Rates

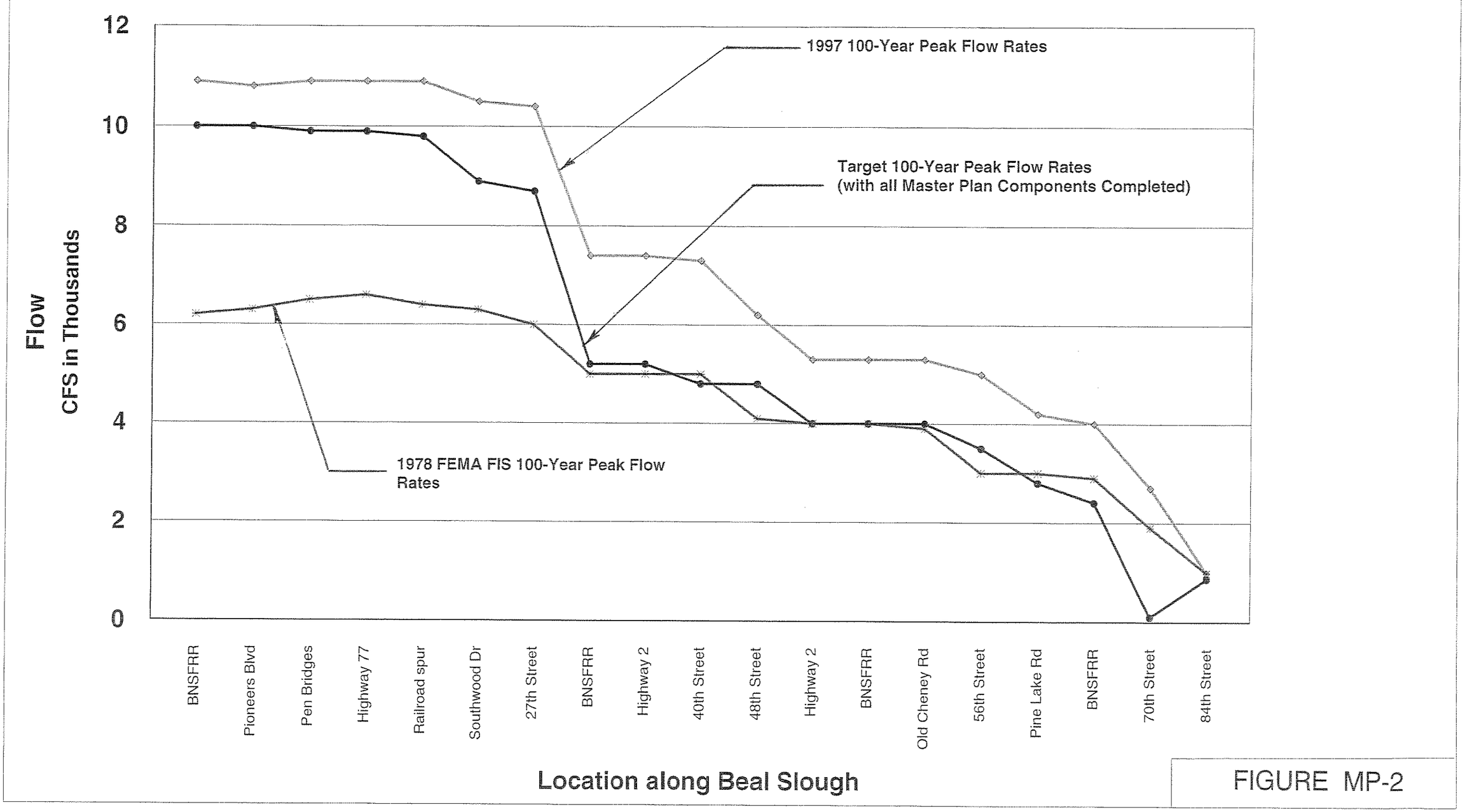
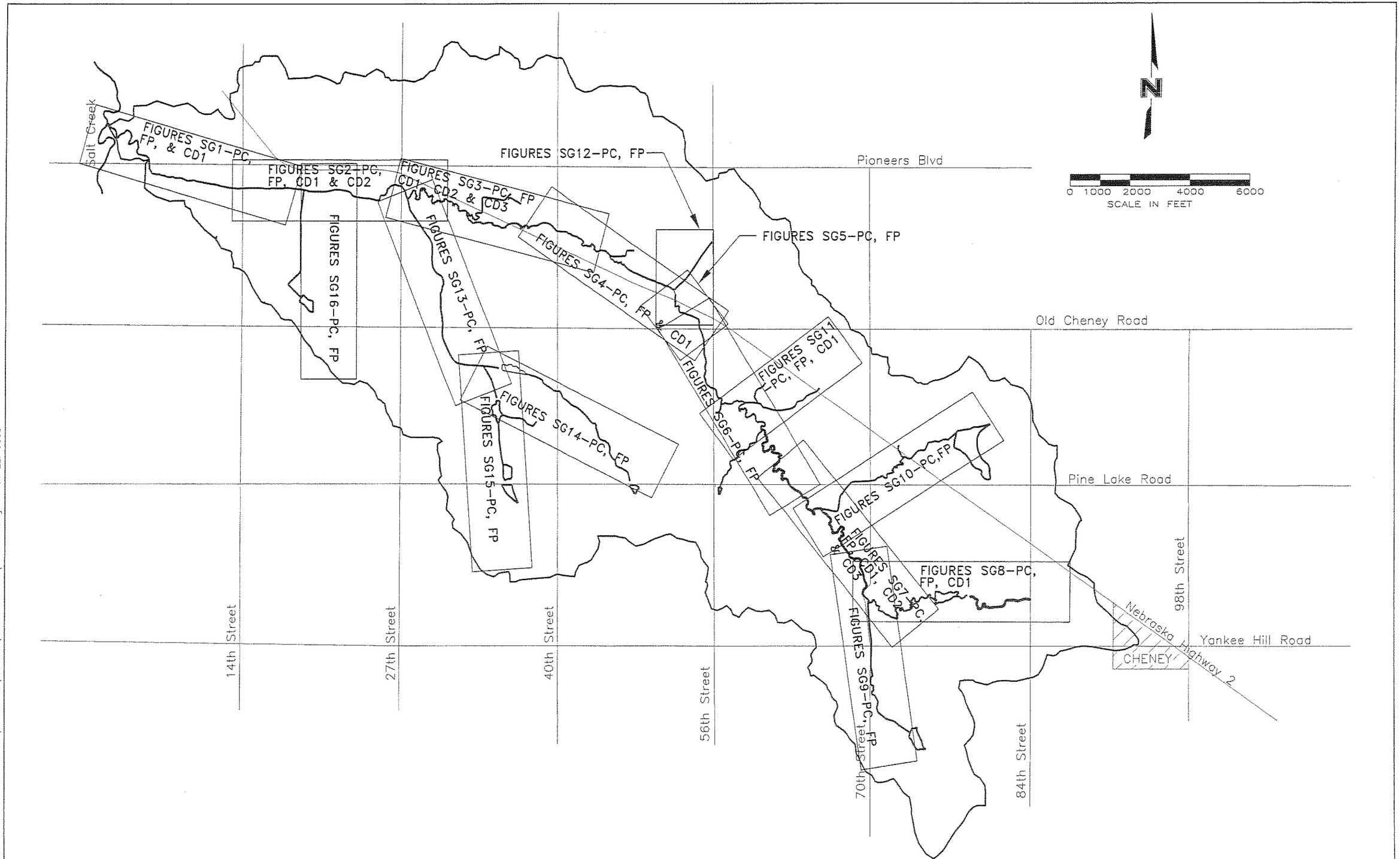
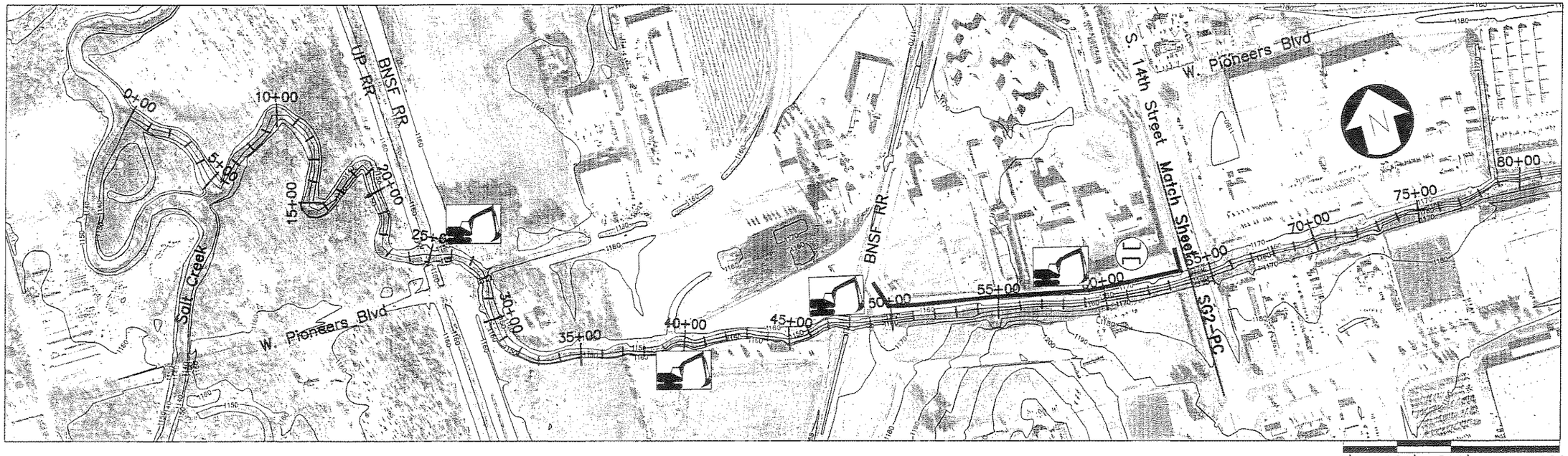


FIGURE MP-2



5/9/2000 10:02 A.M. FILE: F:\PROJECTS\960280\MSTRPLNDWGS\A5FIGVI1.dwg SCALE: 3000

	DRAWN BY: JJM DATE: JUNE 1999 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	**STREAM SEGMENT FIGURE KEY MAP**	**FIGURE MP-3**



Stream Segment 1 Components

Construct tie-back levees to contain 100-year flood.
along north bank from 49+00 to 64+00. **See Figure SG1-CD1**

Rely on BNSF and UP maintenance of grade check under existing bridges near 25+00, 26+00, and 48+00 to maintain bed stability

Add grade checks near 39+00 and 59+00

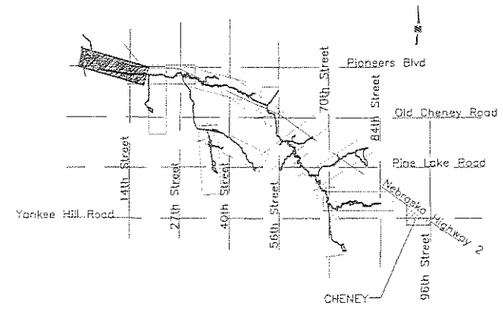
Leave existing natural character of channel within Wilderness Park unless erosion is perceived to be endangering park amenities

Allow natural channel meandering and slope failures from 26+00 to 48+00

Preserve existing floodway and riparian vegetation from 25+50 to 48+00

Preserve existing floodway and reestablish riparian vegetation from 49+50 to 64+00

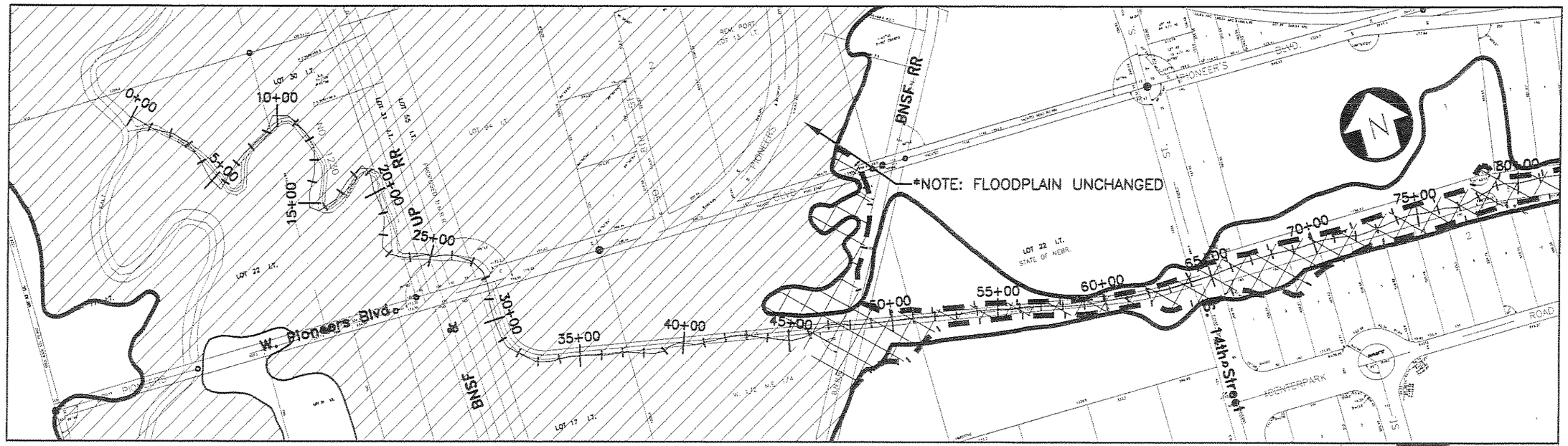
Establish right-of-way from 26+00 to 64+00 for management access



LOCATOR MAP

	DRAWN BY: JJM DATE: JUNE 1999 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 1 COMPONENTS SALT CREEK TO 14th STREET	FIGURE SG1-PC

6/17/1999 4:19 P.M. FILE: F:\Projects\960280\dwg\BSMTCE11adj.dwg SCALE: : 1

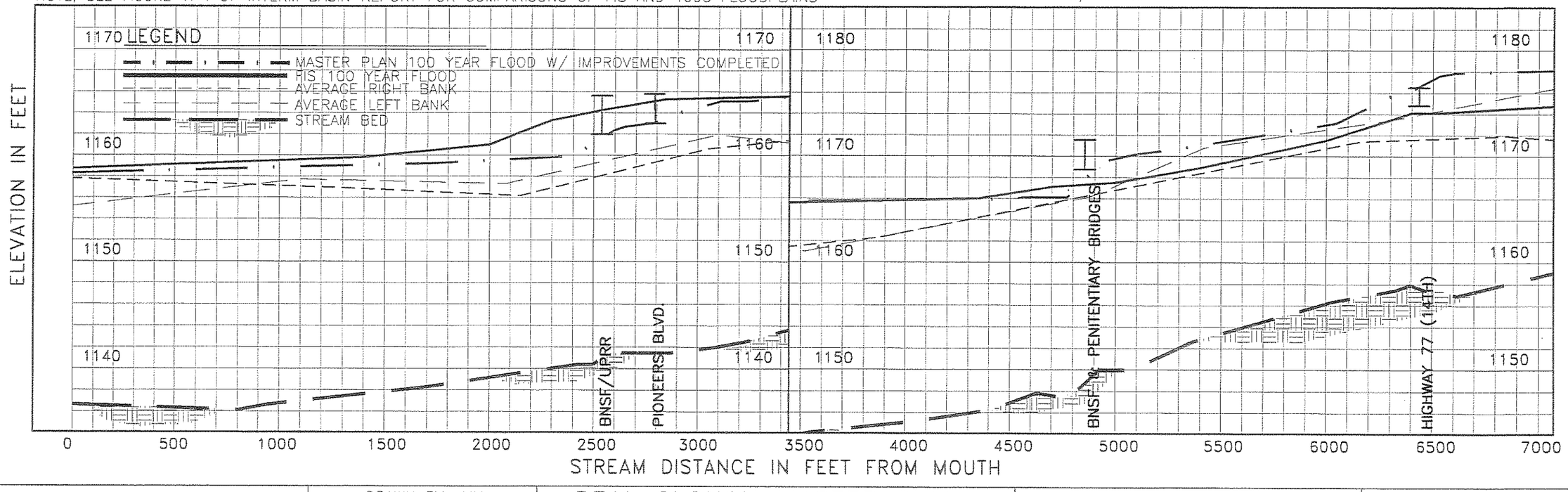


FIS 100 YEAR FLOOD

MASTER PLAN 100 YEAR FLOOD W/ IMPROVEMENTS COMPLETED

0' 250' 500' 1000'

*NOTE; SEE FIGURE VI-1 OF INTERM BASIN REPORT FOR COMPARISONS OF FIS AND 1998 FLOODPLAINS



SCALE: 1" = 500' HORIZONTAL 1" = 10' VERTICAL	DRAWN BY: JJM DATE: 05/20/99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 1 PLAN & PROFILE SALT CREEK TO 14TH STREET	FIGURE SG1-FP

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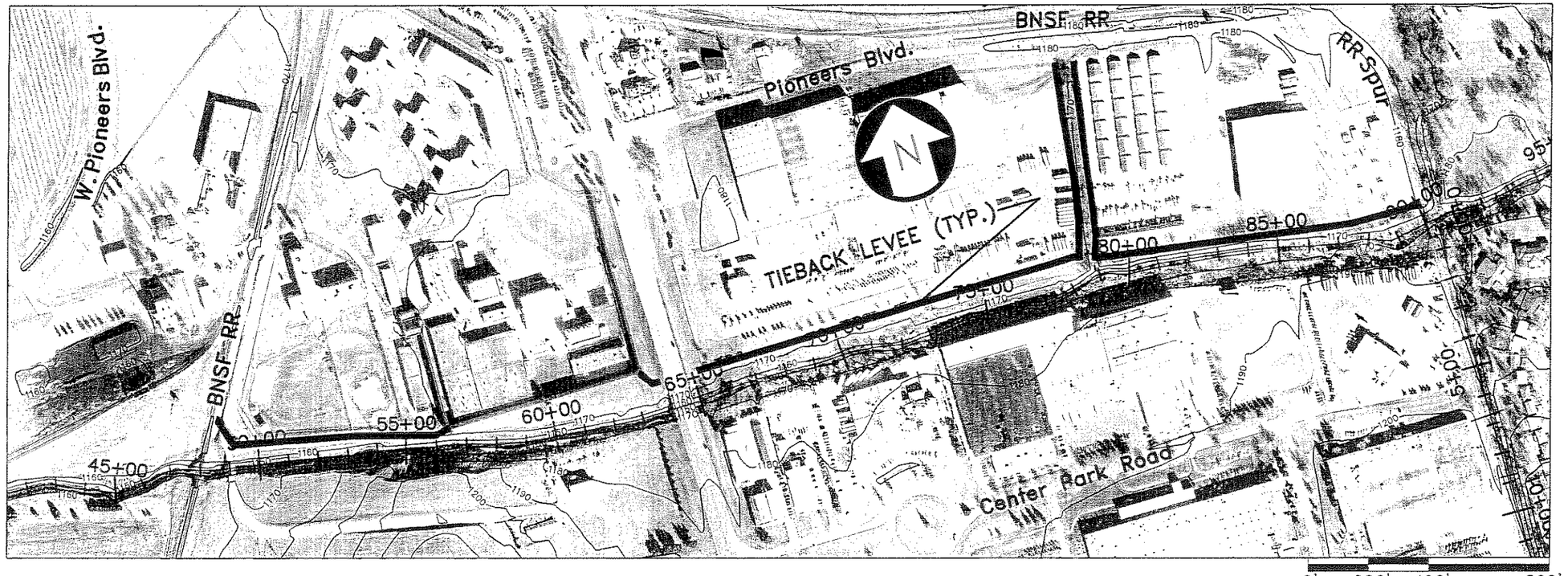

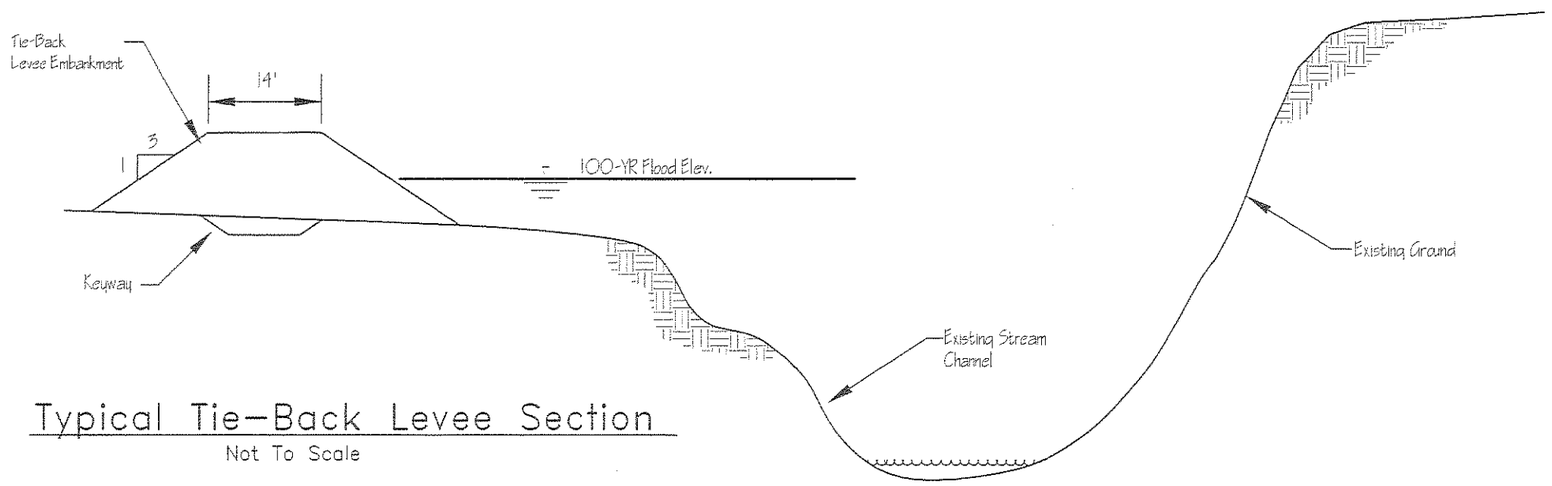

Typical Tie–Back Levee Section

Not To Scale

	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 1 & 2 TIEBACK LEVEE CONCEPT	FIGURE SG1–CD1

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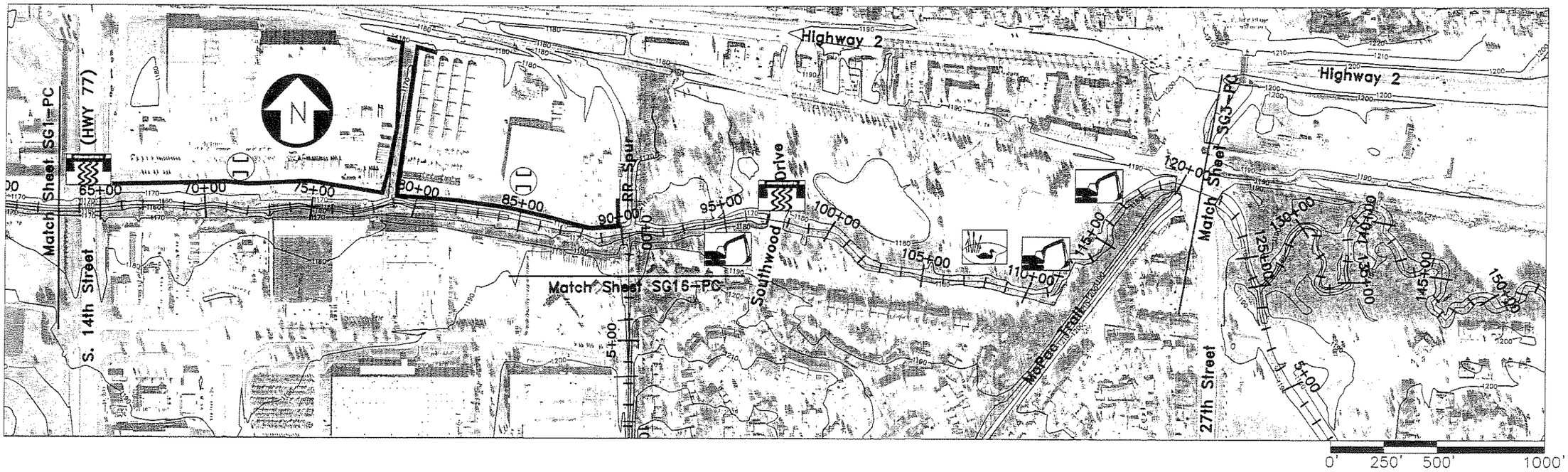


Stream Segment 2 Components

Construct tie back levees to contain 100-year flood (10,000 cfs) along north bank from 65+00 to 90+00 **See Figure SG1-CD1**

Replace NDOR Highway 77 bridge to provide 100-year capacity near 64+00

Replace Southwood Drive structure to provide 50-year capacity near 97+00

Construct channel from 110+00 to 120+00 to improve culvert capacity. **See Figure SG2-CD1**

Channel bed and bank stability improvements construct grade checks near 95+00 and 110+00

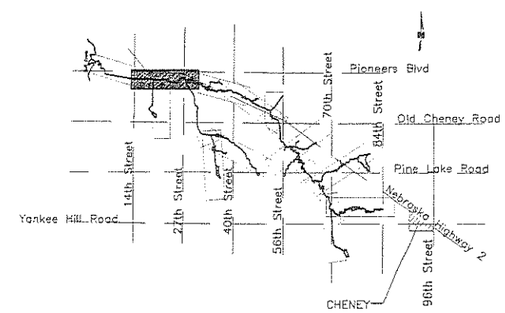
Construct water quality wetland in Ervin E. Peterson Park in conjunction with existing lake.**See Figure SG2-CD2**

Preserve existing floodplain and riparian vegetation from 90+00 to 120+00

Preserve existing floodway and riparian vegetation from 65+00 to 90+00

Protect tributary confluence(s)

Establish right-of-way from 65+00 to 90+00 for management access



LOCATOR MAP

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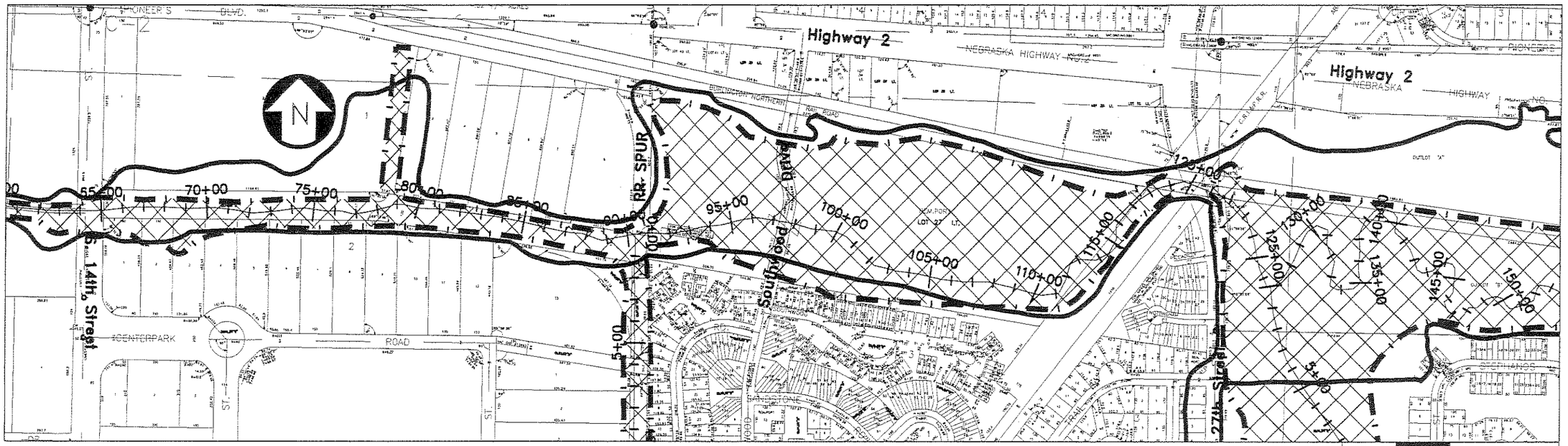
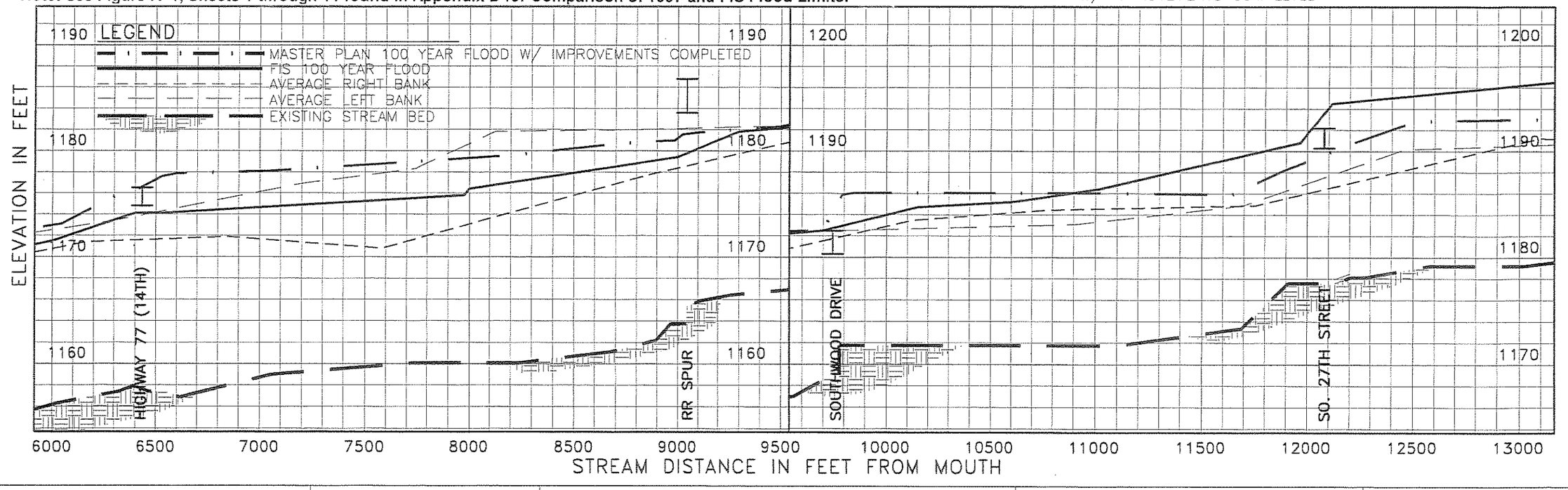


FIS 100 YEAR FLOOD

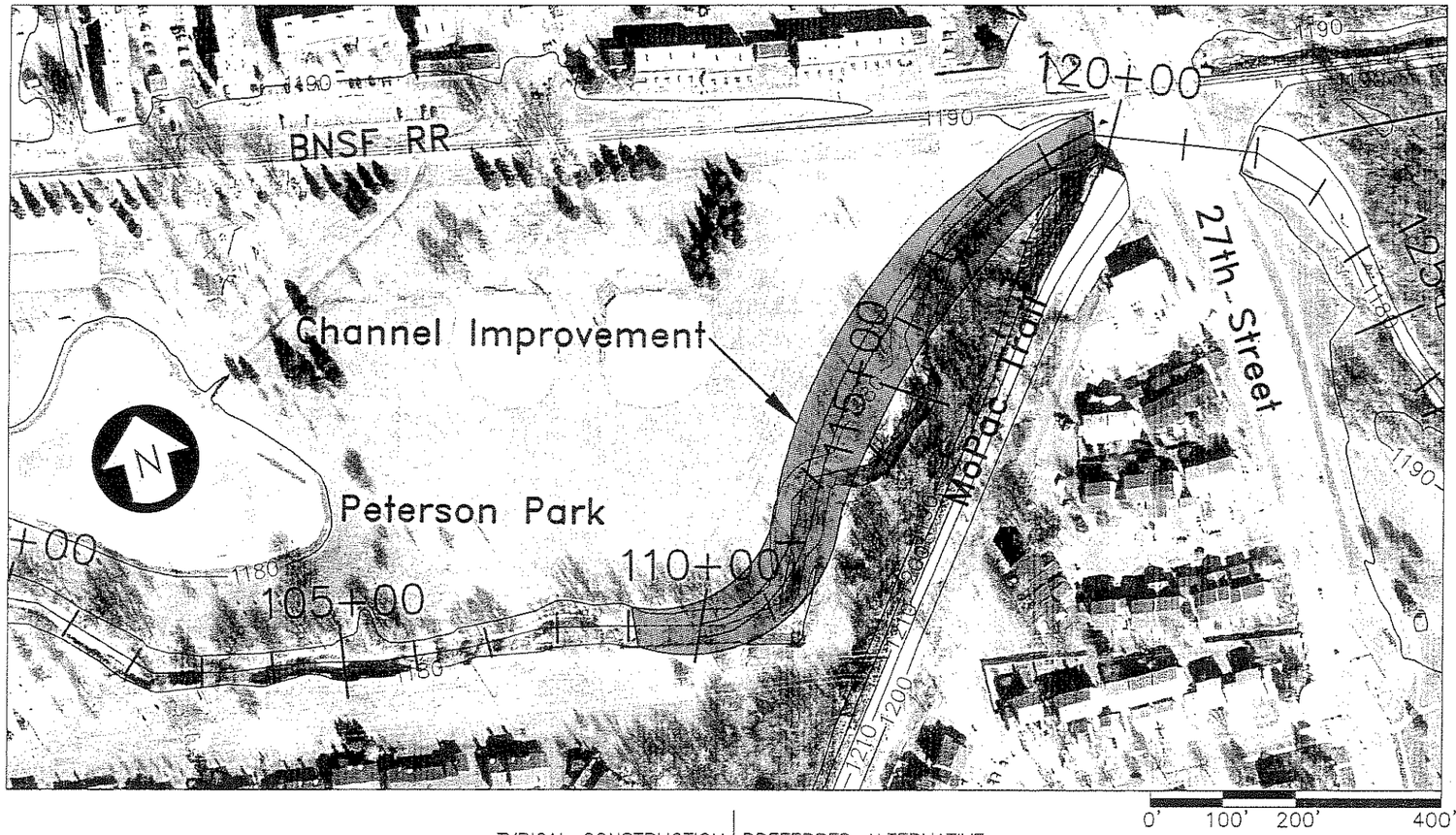
MASTER PLAN 100 YEAR FLOOD W/ IMPROVEMENTS COMPLETED

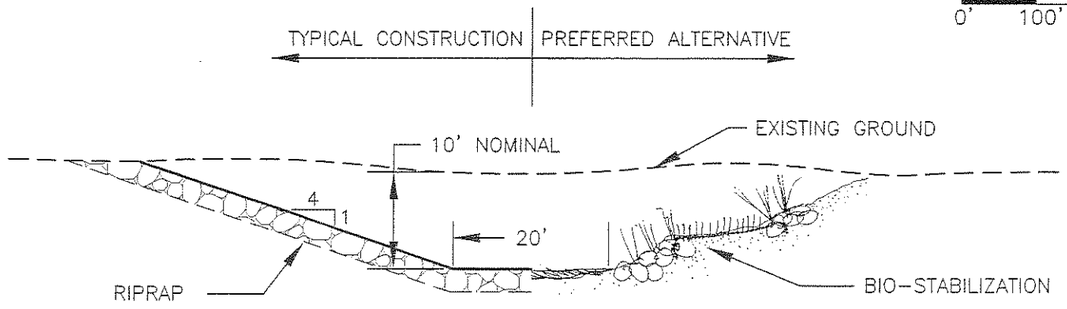
Note: See Figure IV-1, Sheets 1 through 11 found in Appendix B for Comparison of 1997 and FIS Flood Limits.



SCALE: 1" = 500' HORIZONTAL 1" = 10' VERTICAL	DRAWN BY: JJM DATE: 05/20/99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 2 PLAN & PROFILE 14TH STREET TO 27TH STREET	FIGURE SG2-FP

6/24/1999 4:43 P.M. FILE: F:\Projects\960280\dwg\1CSHEET2.dwg SCALE: 1





STA. 110+00 TO 120+00 CHANNEL SECTION (TYP.)

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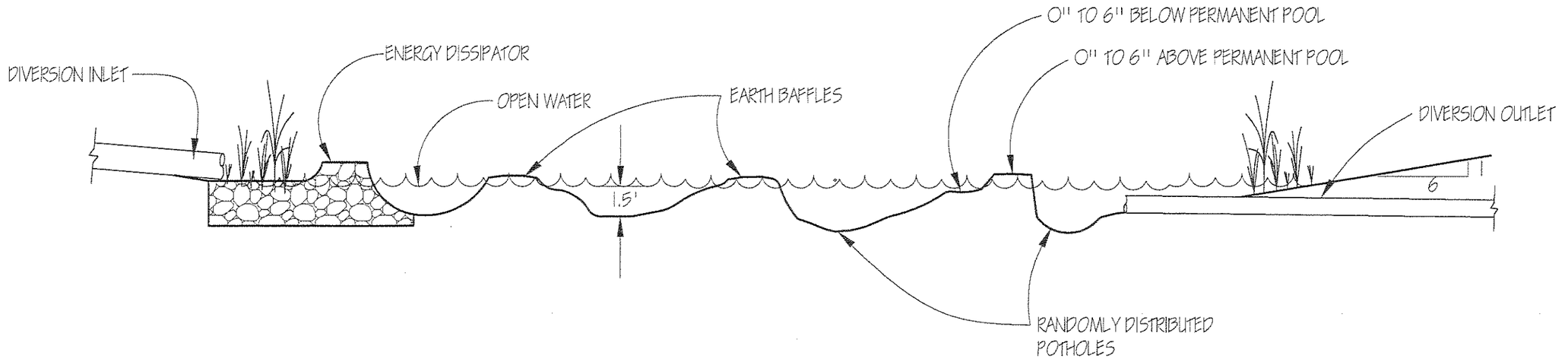

WETLAND CONCEPT CROSS-SECTION

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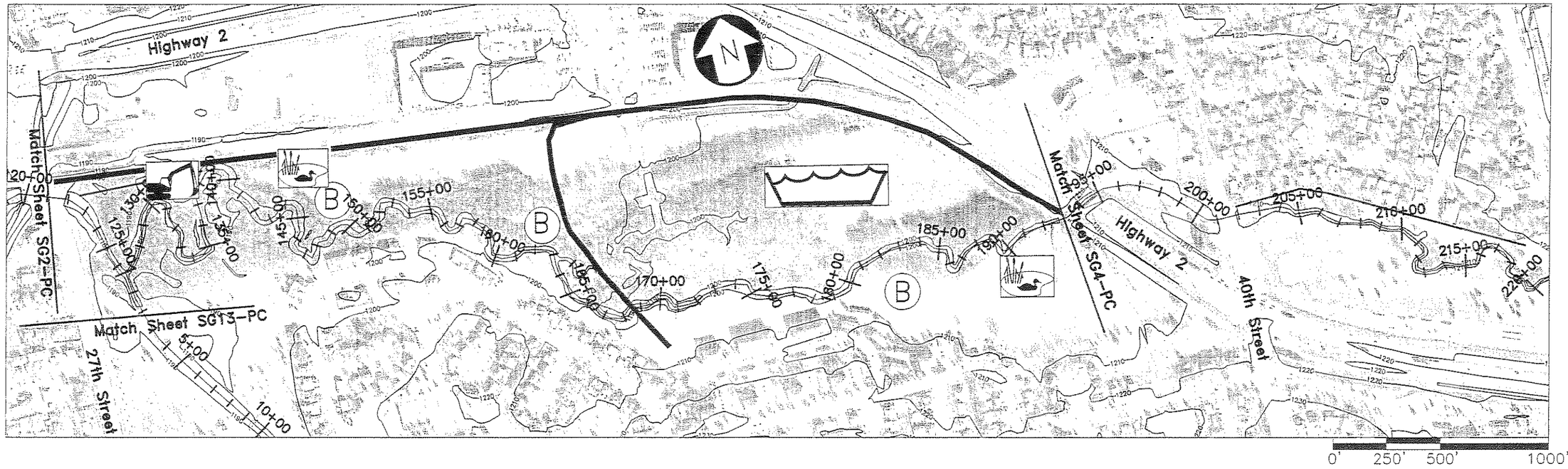


Stream Segment 3 Components

Construct off-channel storage facility in Tierra Park from 162+00 to 194+00
See Figure SG3–CD1 & CD2

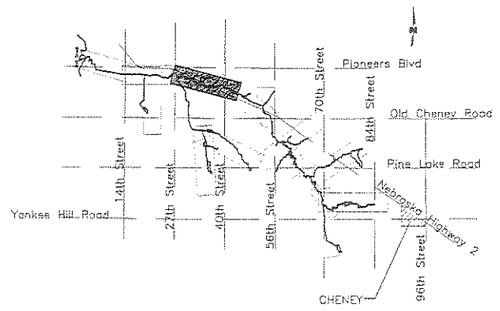
Construct new channel with 5,000 cfs capacity from 121+00 to 195+00 Reestablish riparian vegetation along new channel
See Figure SG3–CD1 & CD2

B — Channel toe and bank stability measures near 147+00, 160+00, and 178+00
See Figure SG3–CD4

Preserve existing floodplain and riparian vegetation from 121+00 to 201+00

Construct water quality wetlands in off-channel storage facility near 190+00
See Figure SG2–CD2

Protect tributary confluences near 126+00 and 163+00



LOCATOR MAP

DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 3 COMPONENTS 27th STREET TO (3800 E) HIGHWAY 2	FIGURE SG3–PC

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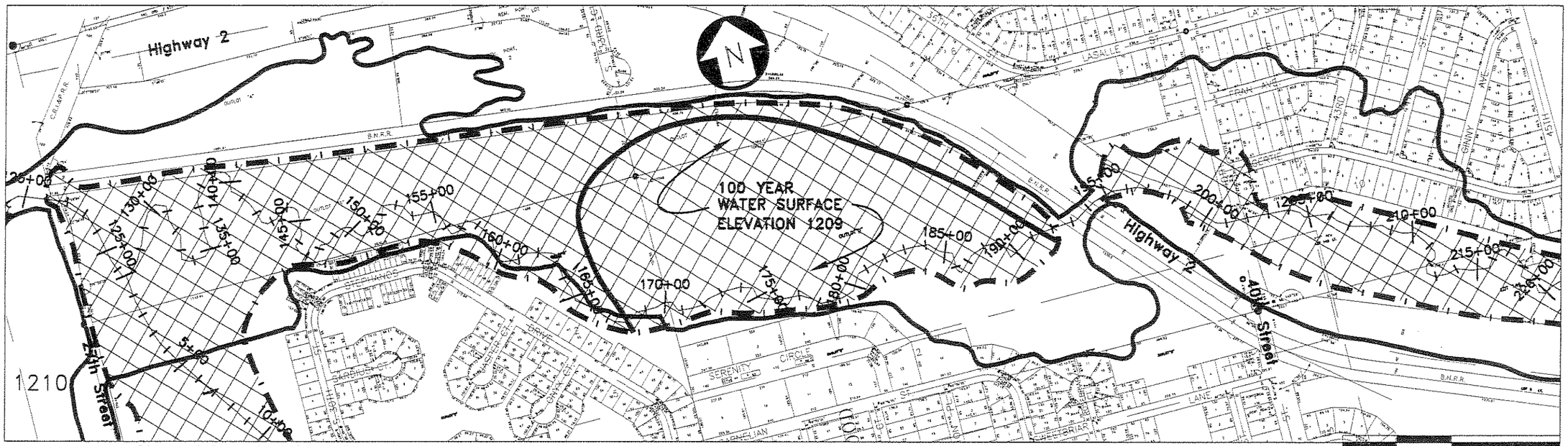
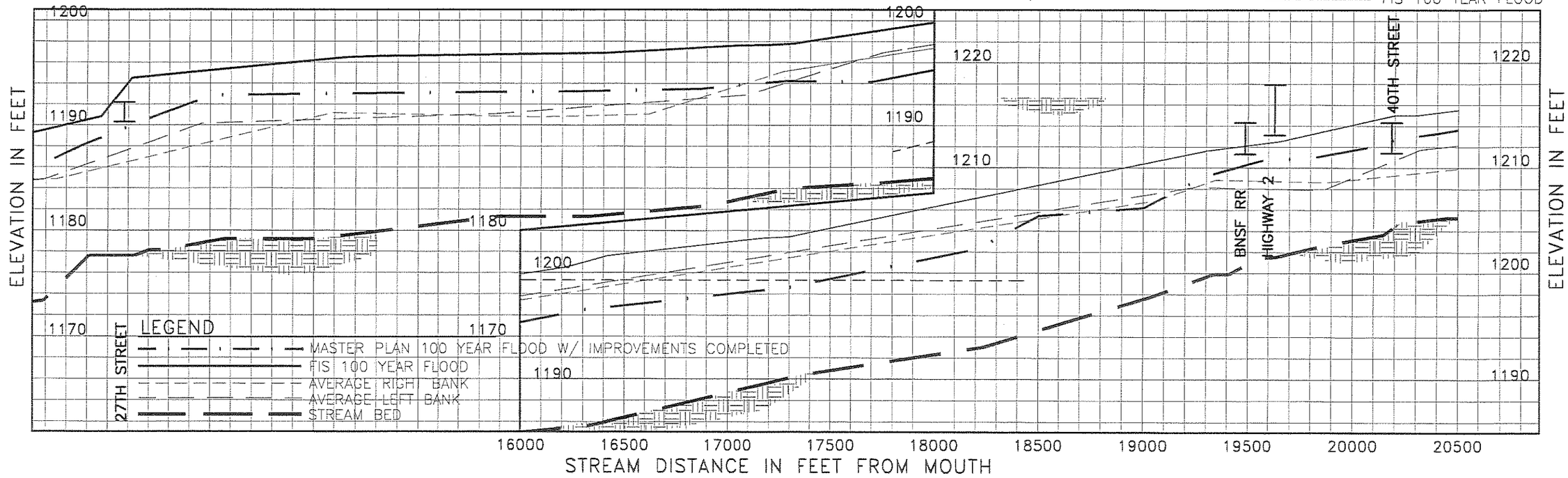


Note: See Figure IV-1, Sheets 1 through 11 found in Appendix B for Comparison of 1997 and FIS Flood Limits.

MASTER PLAN 100 YEAR FLOOD W/ IMPROVEMENTS COMPLETED

FIS 100 YEAR FLOOD

0' 250' 500' 1000'



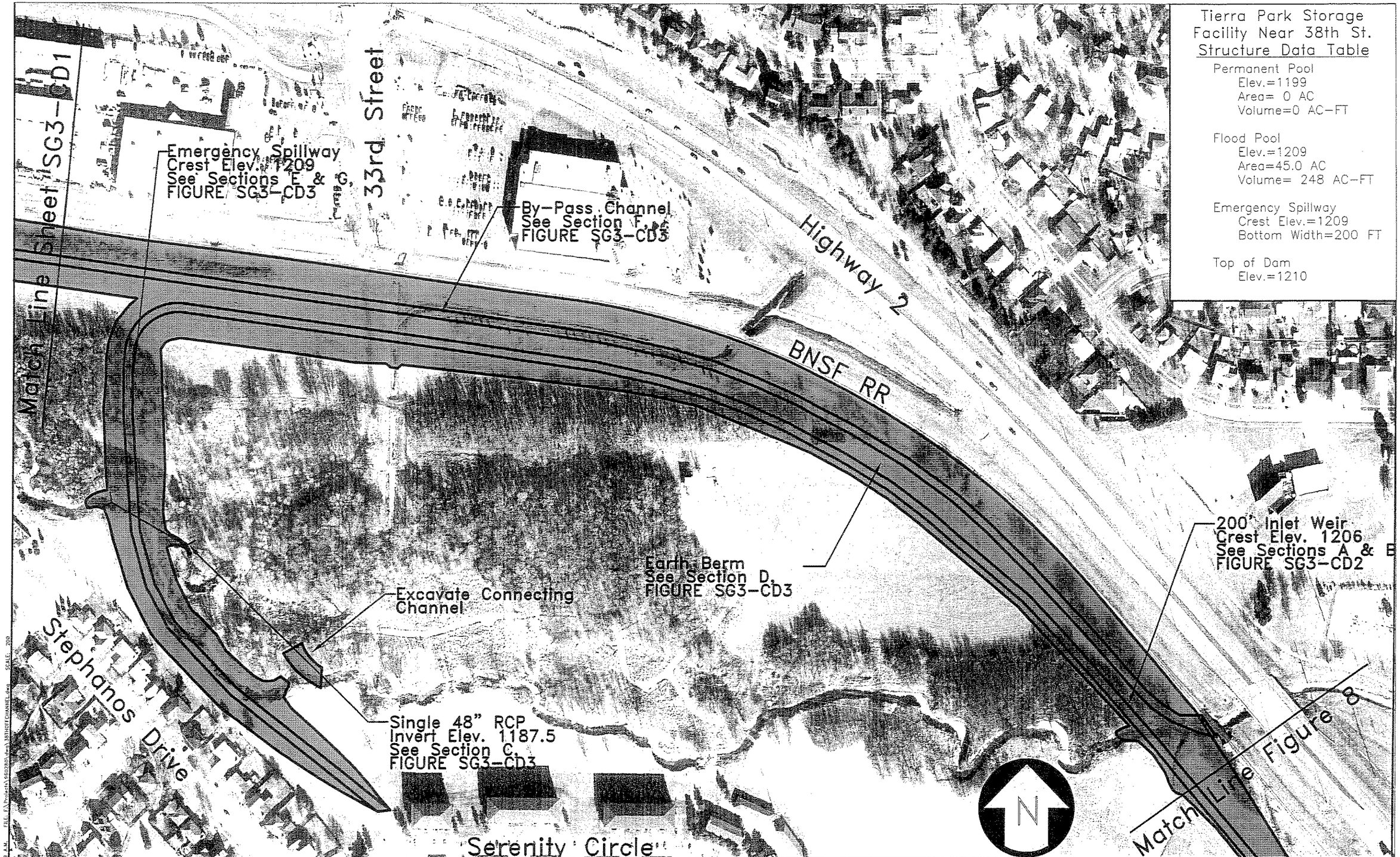
SCALE: 1" = 500' HORIZONTAL 1" = 10' VERTICAL	DRAWN BY: JJM DATE: 05/20/99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 3 PLAN & PROFILE 27TH STREET (3800 E.) HIGHWAY 2	FIGURE SG3-FP

6/24/1999 5:04 P.M. FILE: F:\Projects\960280\dwg\IESHEET3.dwg SCALE: : 10

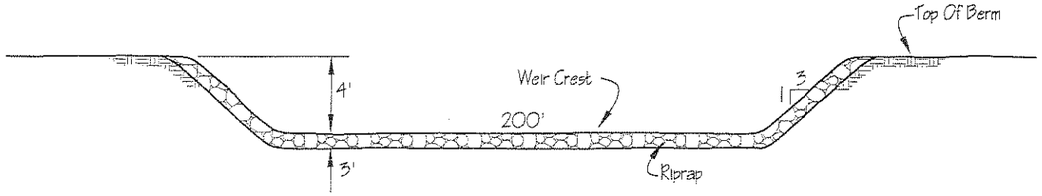
0' 100' 200' 400'	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	TIERRA PARK OFF-CHANNEL STORAGE FACILITY NEAR TIERRA DRIVE

FIGURE SG3-CD1

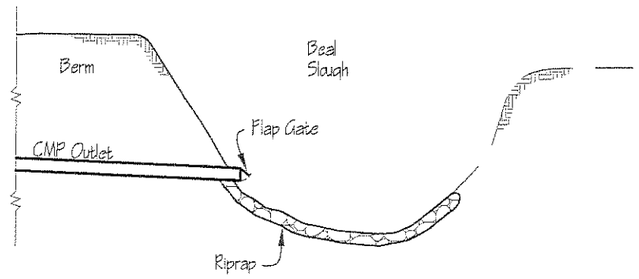
6/25/1999 11:39 A.M. FILE: FA\Projects\980280\dwg\27thDFCHANNEL.dwg SCALE: 200



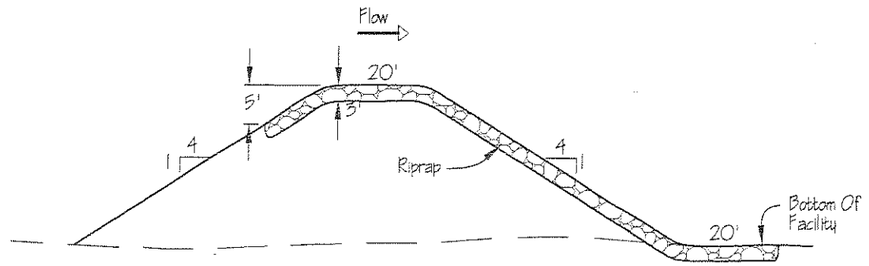
DRAWN BY: JJM DATE: JUNE 1999 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	CONCEPT OFF-CHANNEL STORAGE FACILITY NEAR 38TH STREET	FIGURE SG3-CD2



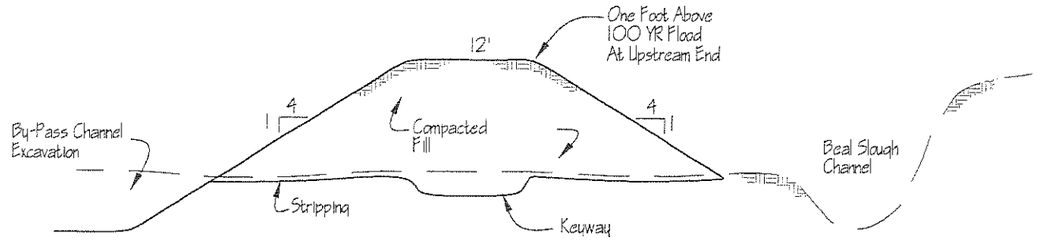
Section A Off-Channel Storage Facility Inlet Weir Profile



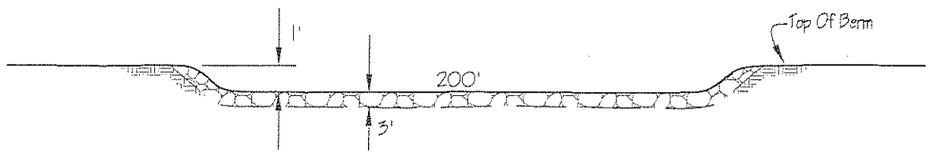
Section C Off-Channel Storage Facility Outlet Detail



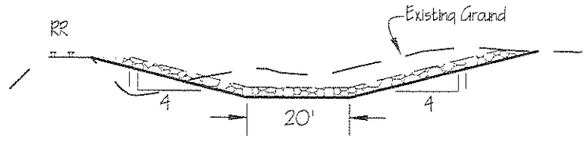
Section B Off-Channel Storage Facility Inlet Weir Cross Section



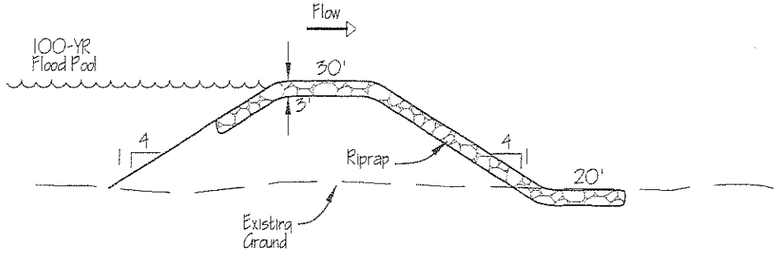
Section D Off-Channel Storage Facility Berm Detail



Section E Off-Channel Storage Facility Emergency Spillway Profile



Section F By-Pass Channel



Section G Off-Channel Storage Facility Emergency Spillway

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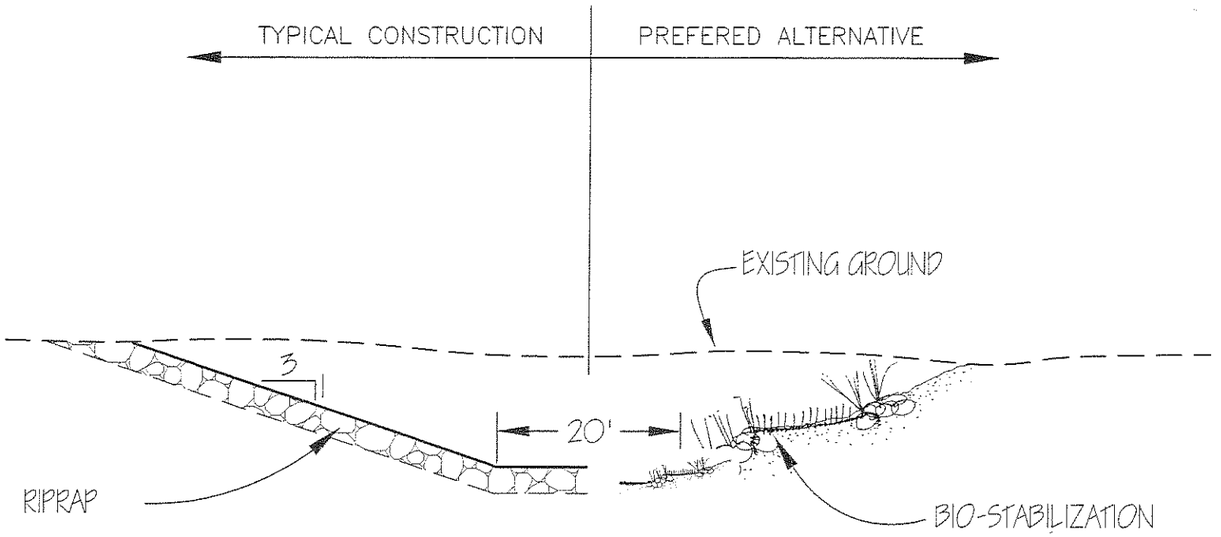

CHANNEL TOE AND BANK STABILITY SECTION

5/9/2000 10:26 A.M. FILE: F:\PROJECTS\960280\MSTRPLNDWGS\B9CONDETS.dwg SCALE: 30

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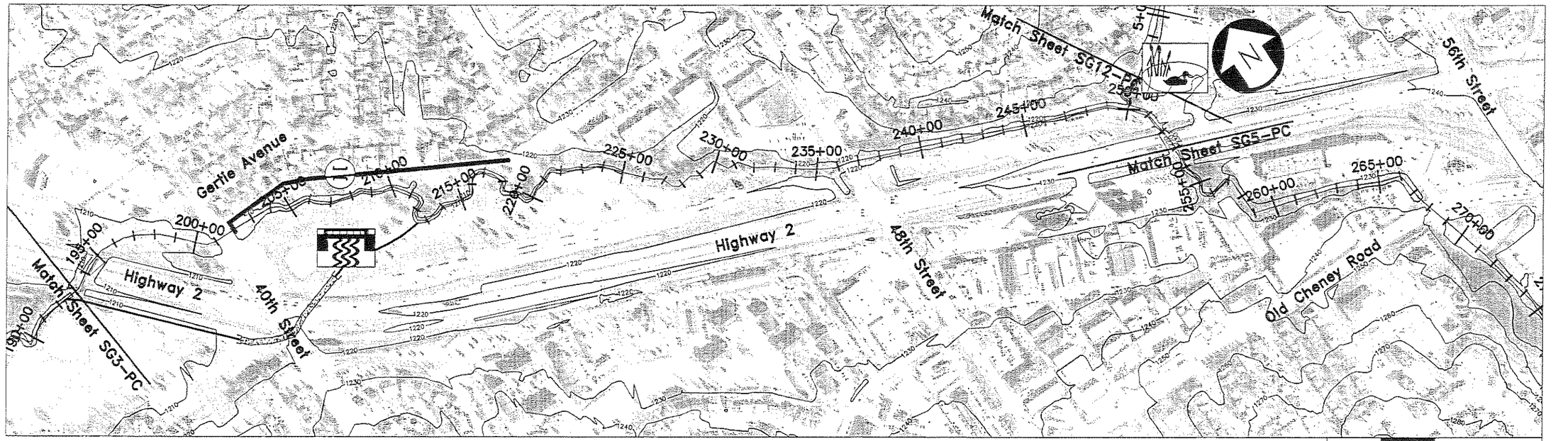


Stream Segment 4 Components

Construct supplementary culvert under intersection of Highway and 40th Street from 194+00 to 213+00 2-barrel 12x8 RC Box and connecting channel **See Figure SG4-CD1**

Construct training dike along north bank from 202+00 to 217+00 and supplement storm drain conduit capacity along Gertie Avenue to west of 40th Street
See Figure SG4-CD1

Improve culvert outlet at 40th Street near 200+00

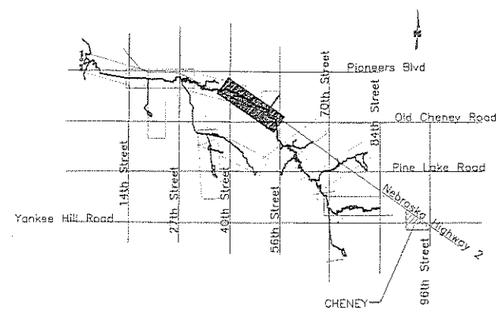
Improve capacity of openings beneath BNSFRR and Highway bridges

Preserve existing floodway, riparian vegetation, and natural channel from 202+00 to 254+00

Protect tributary confluences near 211+00, 225+00, and 250+00

Construct water quality wetland near 250+00 tributary confluence
See Figure SG2-CD2

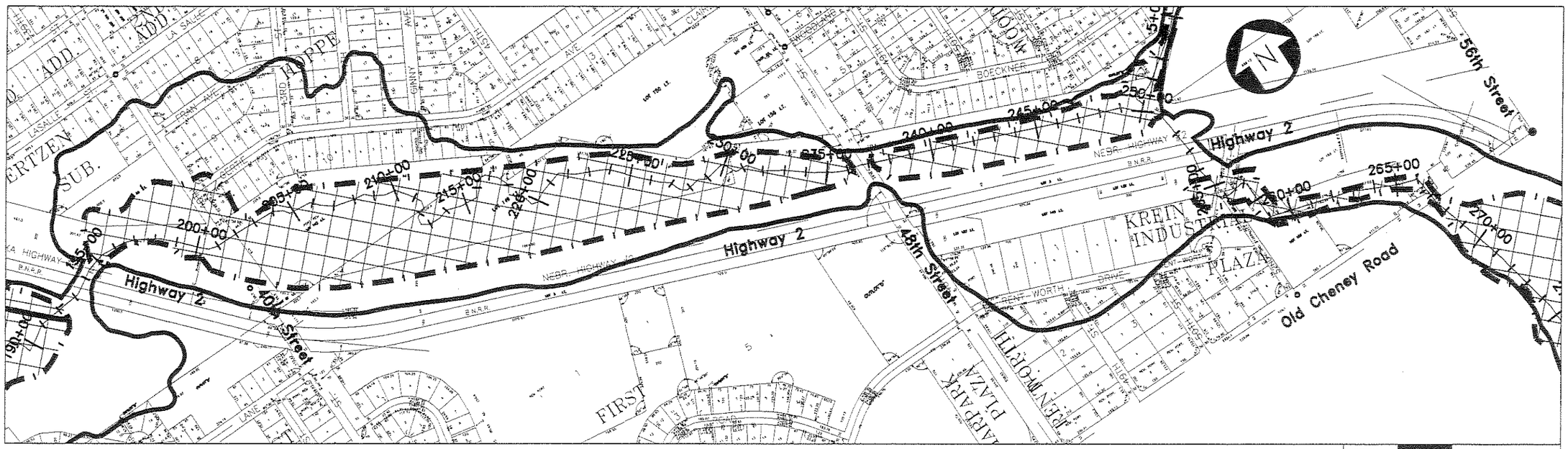
Modify bike path crossing to allow removal of hand railing near 251+00



LOCATOR MAP

	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 4 COMPONENTS (3800E) HIGHWAY 2 TO (5200E) HIGHWAY 2	FIGURE SG4-PC

6/24/1999 9:44 P.M. FILE: F:\Projects\960280\dwg\1HSHEET4adj.dwg SCALE: 1

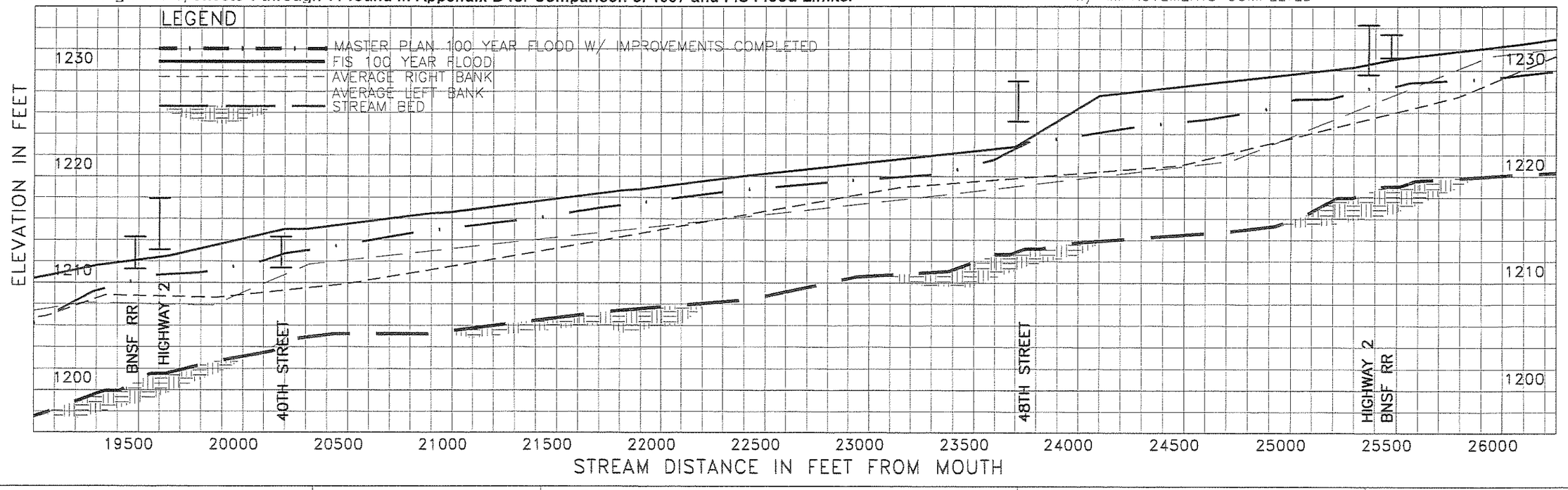


FIS 100 YEAR FLOOD

MASTER PLAN 100 YEAR FLOOD W/ IMPROVEMENTS COMPLETED

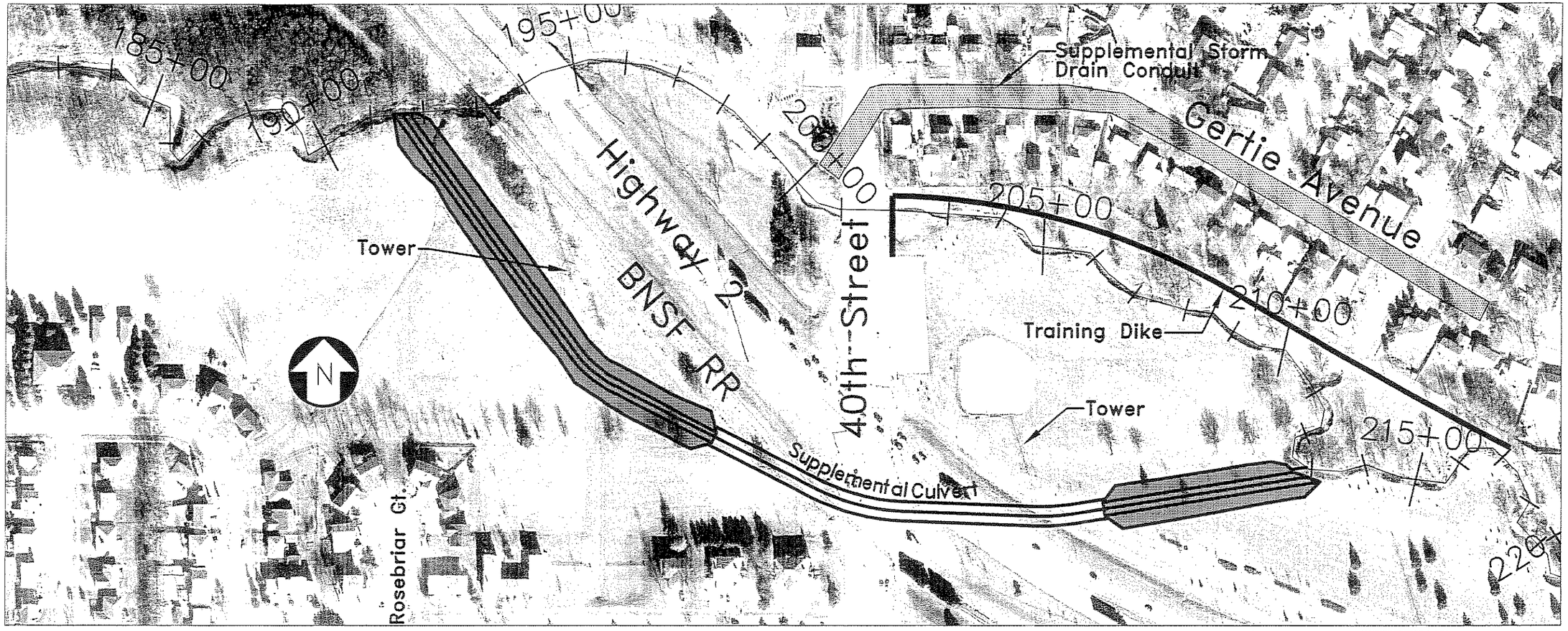
0' 250' 500' 1000'

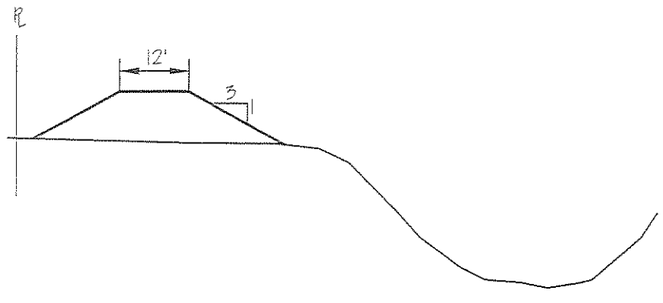
Note: See Figure IV-1, Sheets 1 through 11 found in Appendix B for Comparison of 1997 and FIS Flood Limits.



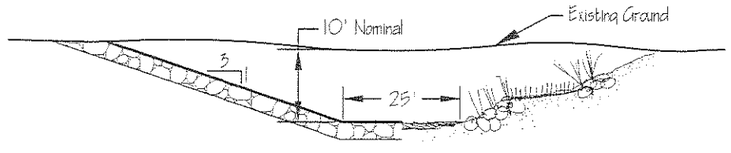
SCALE: 1" = 500' HORIZONTAL 1" = 10' VERTICAL	DRAWN BY: JJM DATE: JUNE 1999 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 4 PLAN & PROFILE (3800 E) HIGHWAY 2 TO (5200 E) HIGHWAY 2	FIGURE SG4-FP

6/24/1999 7:27 P.M. FILE: F:\Projects\960280\dwg\10SHEET4.dwg SCALE: E: 1

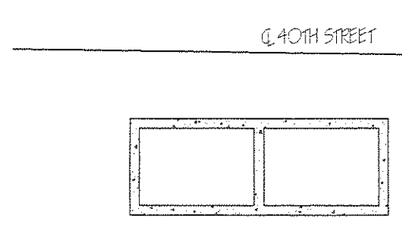




TRAINING DIKE FROM
FROM 202+00 TO 217+00



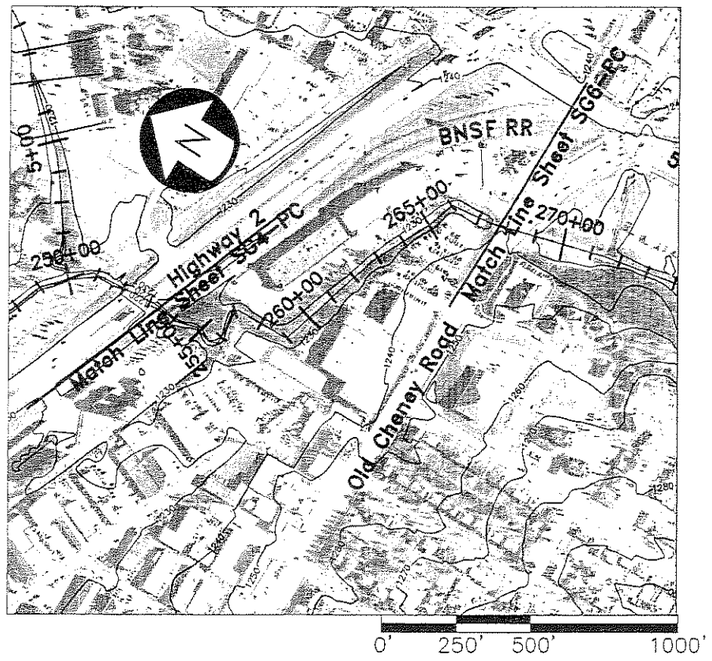
40th Street Supplemental
Channel Section (typ.)



Double 12x8 RCBox

	DRAWN BY: JJM DATE: JUNE 1999 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 4 CONCEPTS	FIGURE SG4-CD1

6/24/1999 7:50 P.M. FILE: F:\Projects\960280\dwg\40THBYPASS.dwg SCALE: 1

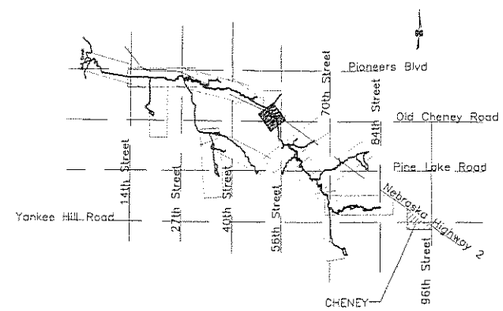


Stream Segment 5 Components

Preserve existing floodway

Establish right-of-way for management access

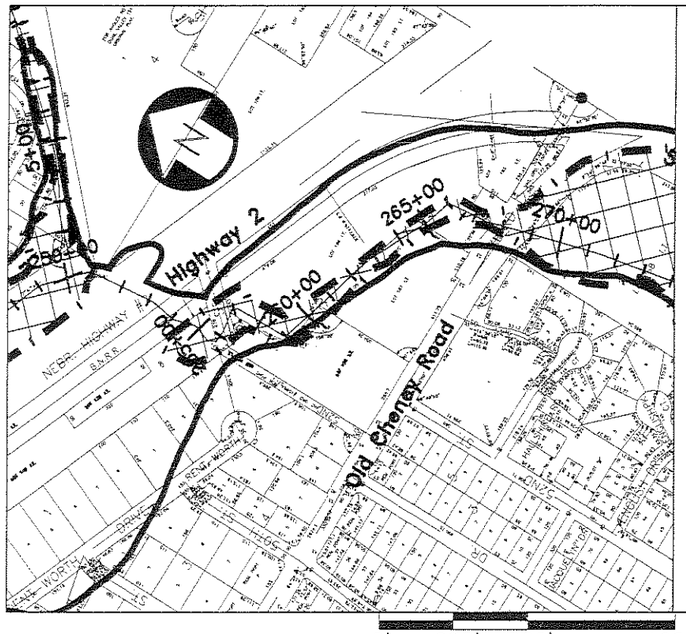
Limit developing subbasin Qp to Master Plan Qp



LOCATOR MAP

	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 5 COMPONENTS (5200E) HIGHWAY 2 TO OLD CHENEY ROAD	FIGURE SG5-PC

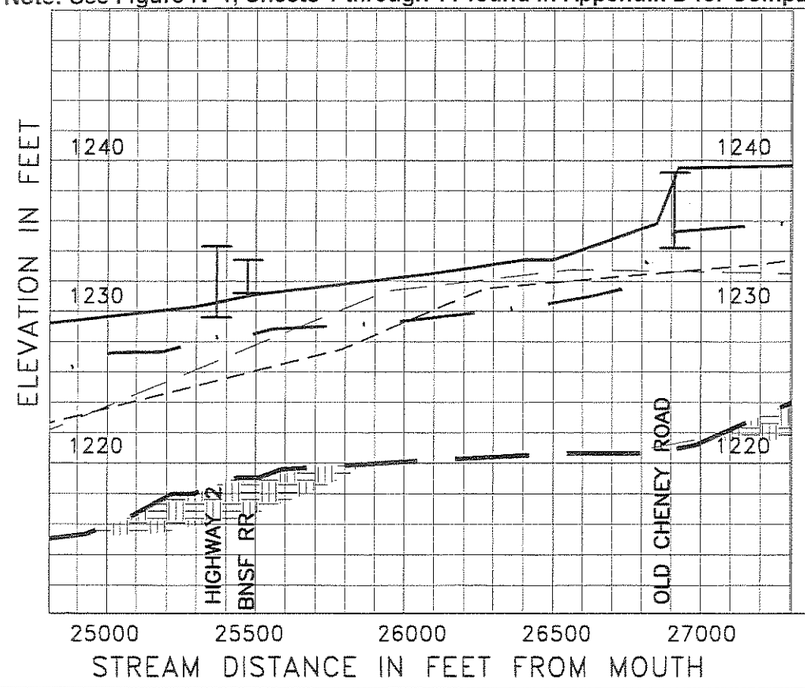
6/24/1999 8:21 P.M. FILE: F:\Projects\960280\dwg\JJSHEET5adj.dwg SCALE: 1



FIS 100 YEAR FLOOD

MASTER PLAN 100 YEAR FLOOD W/ IMPROVEMENTS COMPLETED

Note: See Figure IV-1, Sheets 1 through 11 found in Appendix B for Comparison of 1997 and FIS Flood Limits.

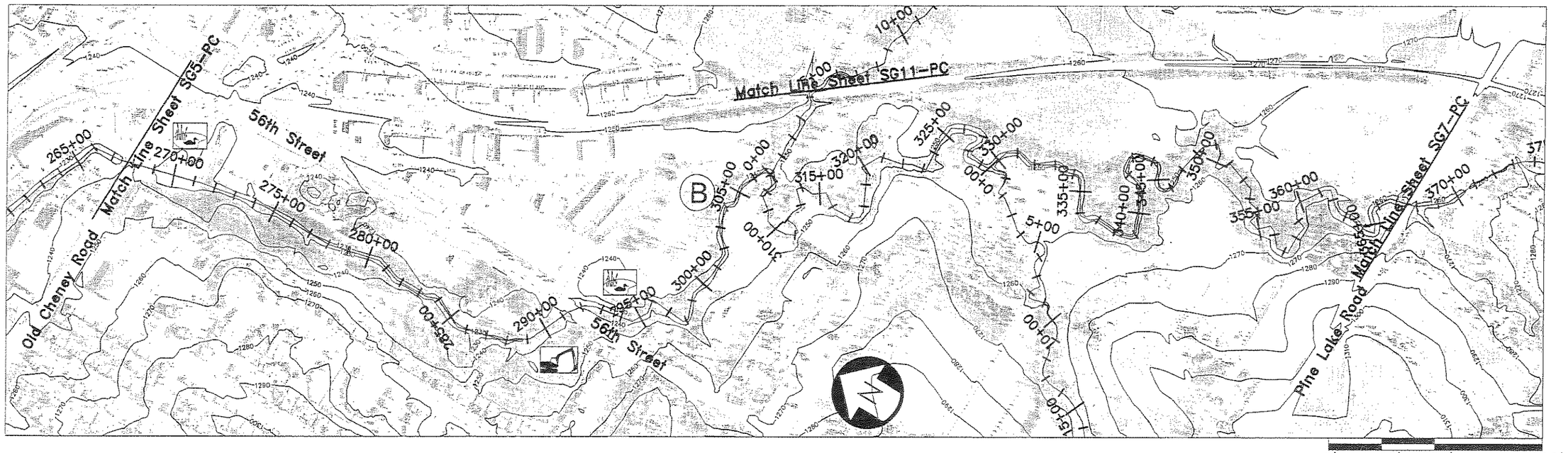


LEGEND

- MASTER PLAN 100 YEAR FLOOD W/ IMPROVEMENTS COMPLETED
- FIS 100 YEAR FLOOD
- AVERAGE RIGHT BANK
- AVERAGE LEFT BANK
- EXISTING STREAM BED

SCALE: 1" = 500' HORIZONTAL 1" = 10' VERTICAL	DRAWN BY: JJM DATE: 05/20/99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	**STREAM SEGMENT 5 PLAN & PROFILE (5200 E) HIGHWAY 2 TO OLD CHENNY RD**	**FIGURE SG5-FP**

6/10/1999 8:04 A.M. FILE: F:\Projects\960280\dwg\IISHEET5.dwg SCALE: E: 1



Stream Segment 6 Components

Construct water quality wetland near 270+00 and near 295+00
See Figure SG2-CD2

Channelization and stability treatment from 284+00 to 294+00
See Figure SG3-CD4

Enlarge 56th Street bridge opening near 292+00

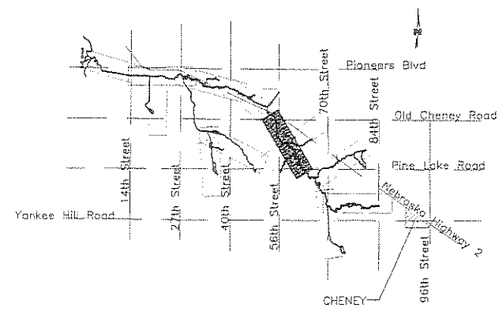
B — Channel stability improvement from 294+00 to 306+00 and reestablish natural character and riparian vegetation
See Figure SG3-CD4

Protect tributary confluences near 306+00 and 329+00

Preserve existing floodway, riparian vegetation, and natural channel from 269+00 to 368+00

Establish right-of-way from 269+00 to 292+00 and from 306+00 to 368+00 for management access

Limit developing subbasin Qp to Master Plan Qp

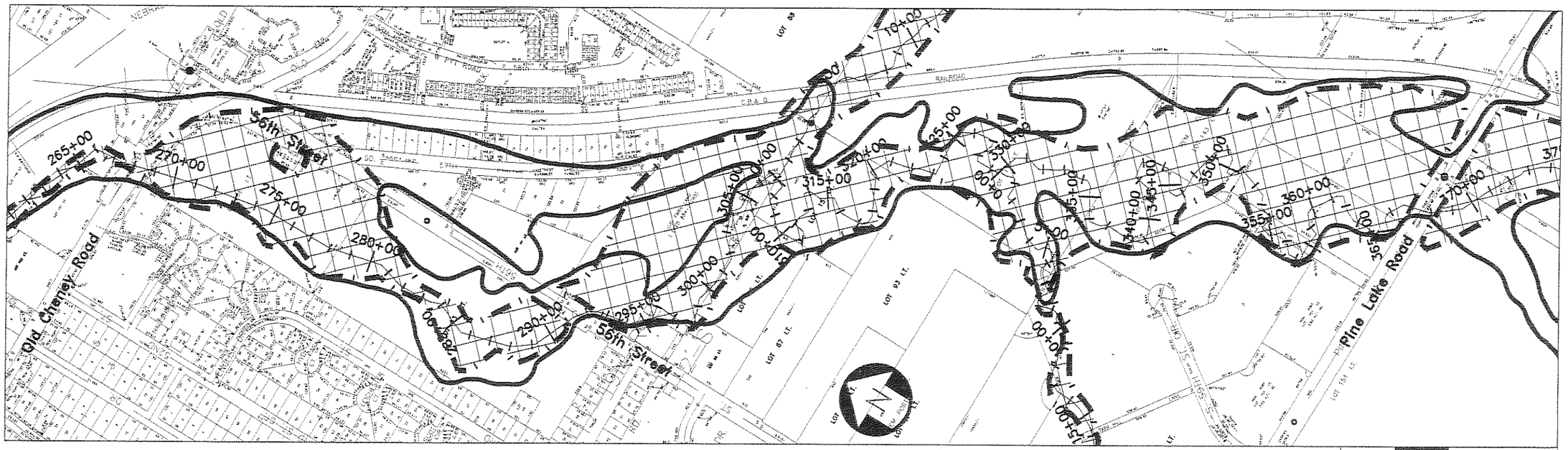


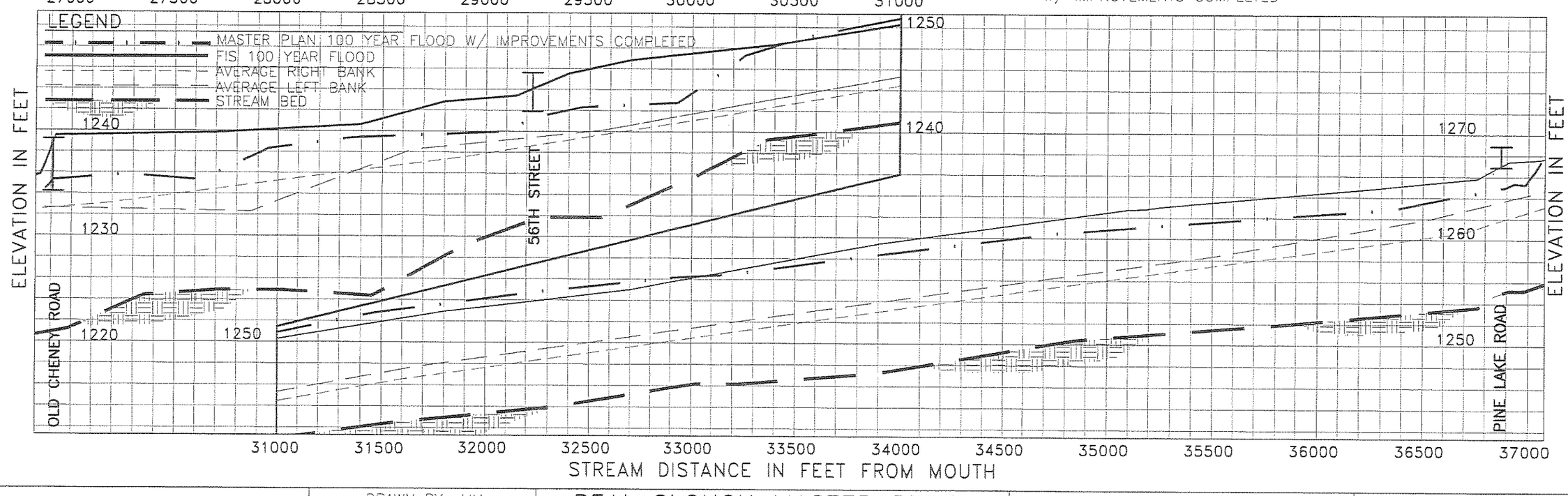
LOCATOR MAP

	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 6 COMPONENTS OLD CHENEY ROAD TO PINE LAKE ROAD	FIGURE SG6-PC

6/24/1999 8:39 P.M. FILE: F:\Projects\960280\dwg\TLSHEET\sg6.dwg SCALE: E: 1

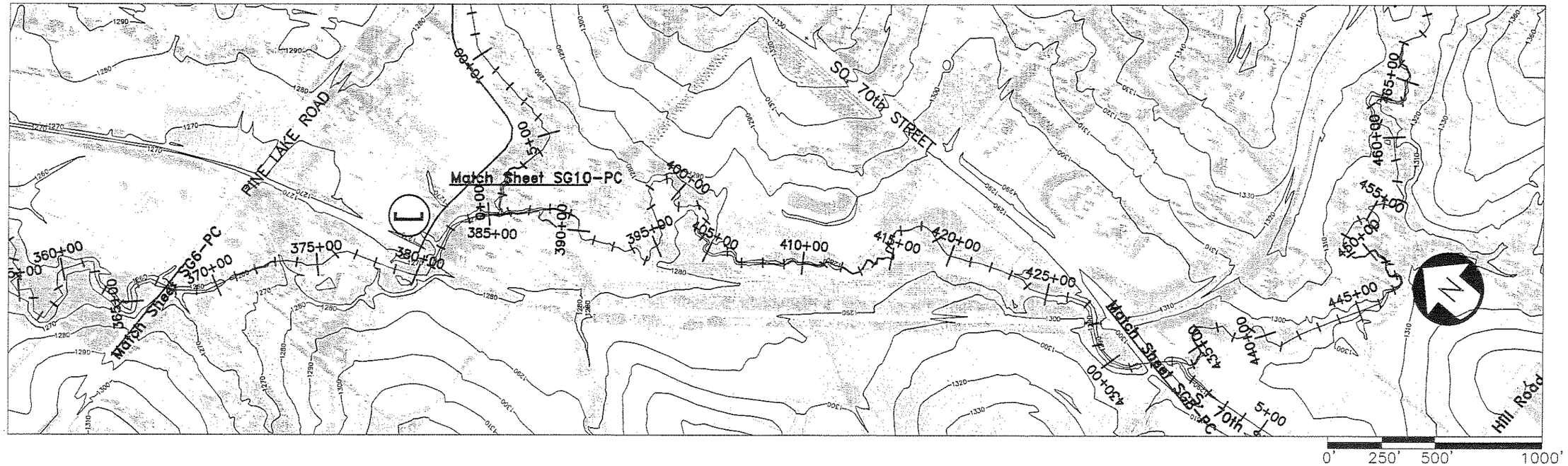
Note: See Figure IV-1, Sheets 1 through 11 found in Appendix B for Comparison of 1997 and FIS Flood Limits.





SCALE: 1" = 500' HORIZONTAL 1" = 10' VERTICAL	DRAWN BY: JJM DATE: JUNE 1999 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 6 PLAN & PROFILE OLD CHENEY RD TO PINE LAKE RD	FIGURE SG6-FP

6/29/1999 12:04 P.M. FILE: F:\Projects\969280\dwg\IKSHEETS.dwg SCALE: E: 1



Stream Segment 7 Components

Incorporate one or more stormwater storage facilities that provide target peak flowrate reduction from Sub Area G, **See Figure MP-1**

Rework private stream crossings near 371+00 and 374+00

Construct training dike at BNSFRR to utilize full bridge capacity & acquire upstream floodplain easement, **See Figure SG7-CD2**

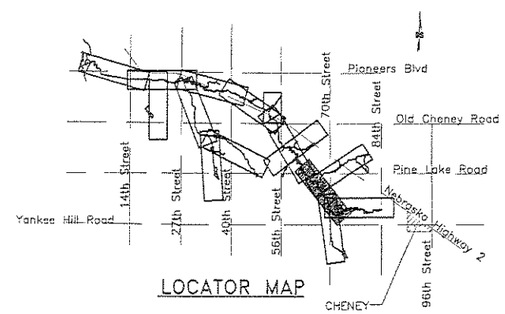
Protect tributary confluences near 368+00, 385+00, 388+00, and 430+00

Maintain existing private grade stabilization ponds for water quality and channel stability on tributary south of 368+00

Preserve existing floodway, riparian vegetation, and natural channel from 368+00 to 433+00

Establish right-of-way for management access

Limit developing subbasin Qp to Master Plan Qp

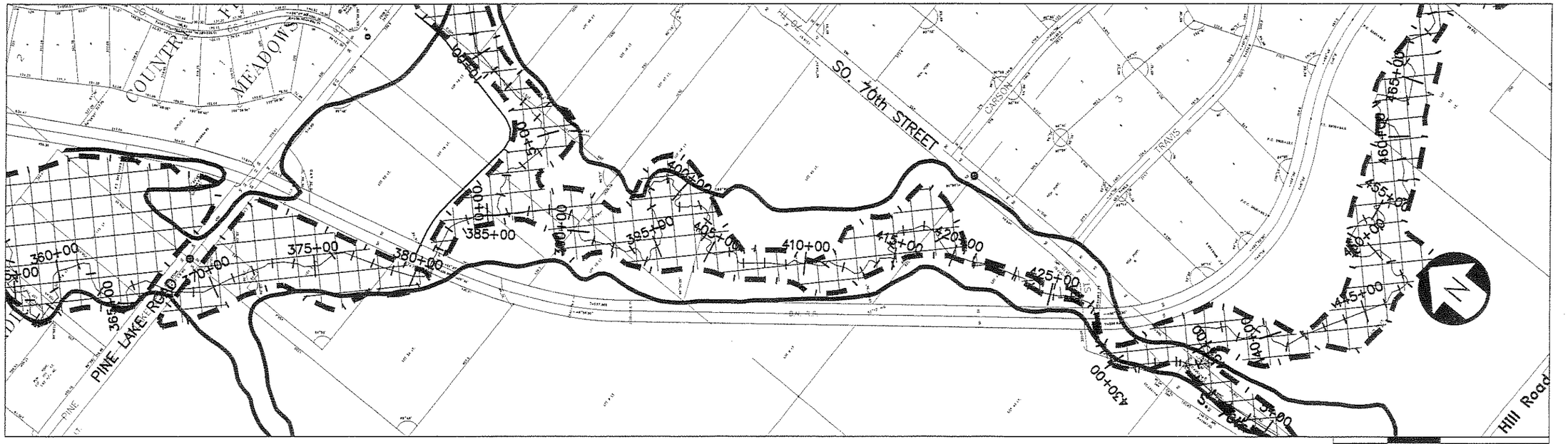


LOCATOR MAP

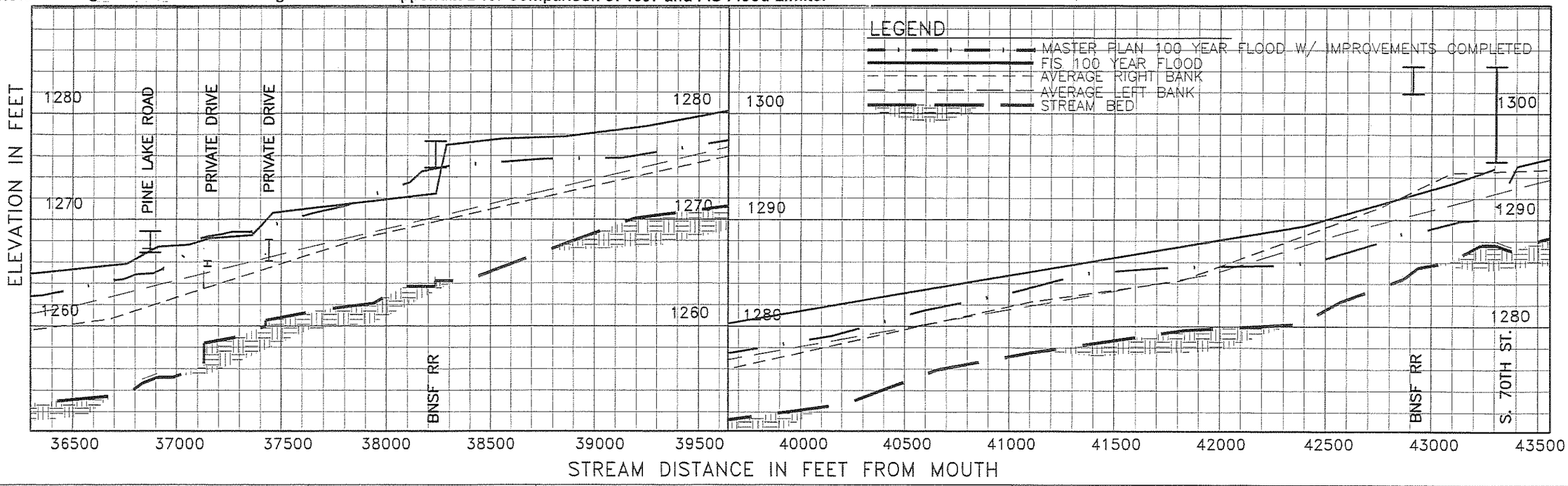
	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	**STREAM SEGMENT 7 COMPONENTS** **PINE LAKE ROAD TO 70th STREET**

Figure SG7-PC

6/24/1999 10:08 P.M. FILE: F:\Projects\960280\dwg\INSHEET7adj.dwg SCALE: E: 1

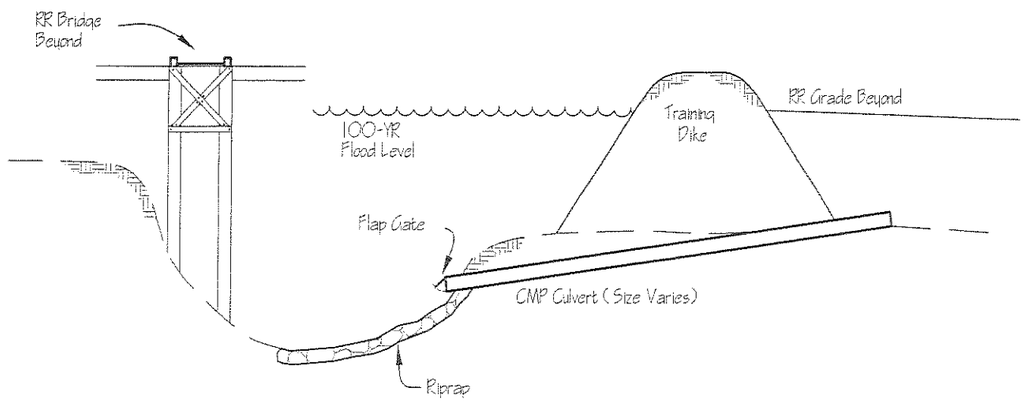


Note: See Figure IV-1, Sheets 1 through 11 found in Appendix B for Comparison of 1997 and FIS Flood Limits.



SCALE: 1" = 500' HORIZONTAL 1" = 10' VERTICAL	DRAWN BY: JJM DATE: 05/20/99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	**STREAM SEGMENT 7 PLAN & PROFILE PINE LAKE RD TO 70TH STREET**	**FIGURE SG7-FP**

6/24/1999 9:11 P.M. FILE: F:\Projects\960280\dwg\1MSHEET7.dwg SCALE: E: 1



BNSF RR BRIDGE & TRAINING DIKE NEAR 382+00

Pine Lake Road

Grade From Existing Ground Down 2' @ 3:1
1% Slope to Existing Creek

Pine Lake

Tributary From

Borrow Areas

Interior Drainage Swale

Top Of Dike, Elev. 1279.6

BNSF RR

Beal

Slough

0 25 50 100

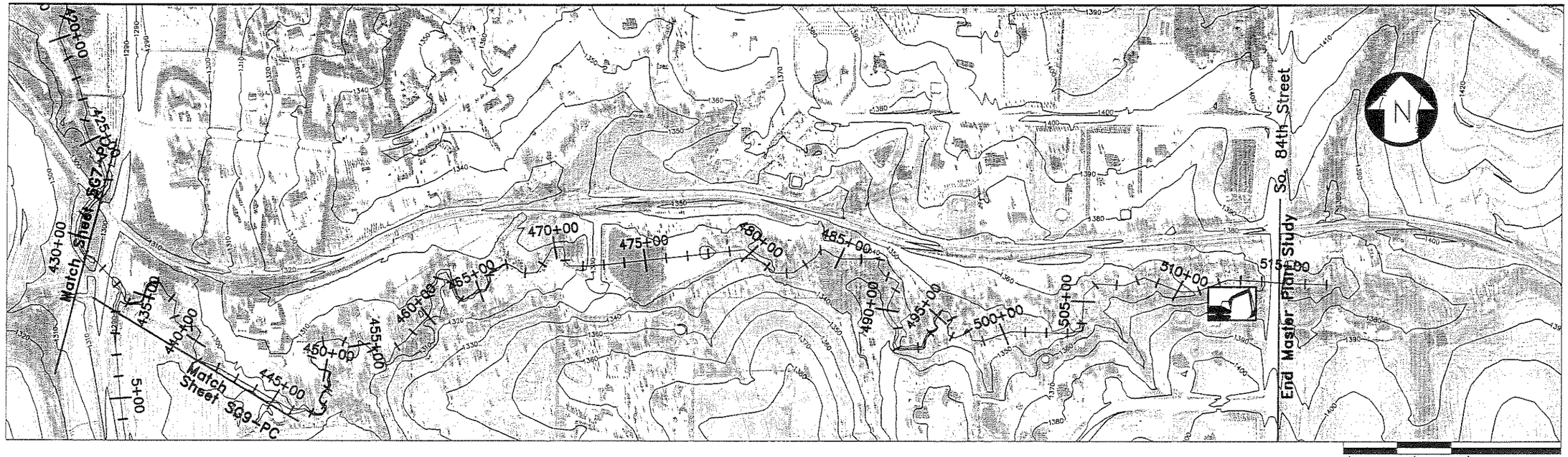
DRAWN BY: JJM
DATE: JUNE 1999
REVISIONS:

BEAL SLOUGH MASTER PLAN
LINCOLN, NEBRASKA

TRAINING DIKE CONCEPT

FIGURE SG7-CD1

6/24/1999 8:34 P.M. FILE: F:\Projects\98025\dwg\trainfin.dwg SCALE: 100



Stream Segment 8 Components

Incorporate one or more stormwater storage facilities that provide target peak flowrate reductions from Sub Areas D & E,
See Figure MP-1, Table MP-1, and Table MP-2

Protect tributary confluences near 434+00, 449+00, and 466+00

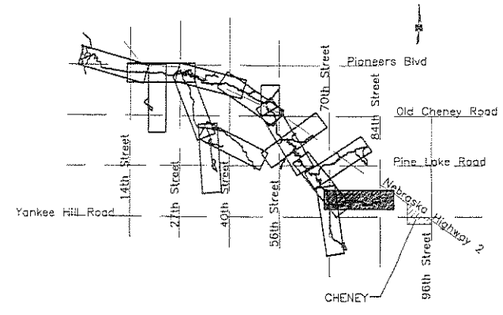
Perpetuate existing grade stabilization structure near 474+00 for quality improvement and channel stability

Clean out 84th Street RC Box Culvert outlet channel from 513+00 to 516+00

Preserve existing floodplain, riparian vegetation, and natural channel from 429+00 to 516+00

Establish right-of-way from 434+00 to 516+00 for management access

Limit developing subbasin Qp to Master Plan Qp

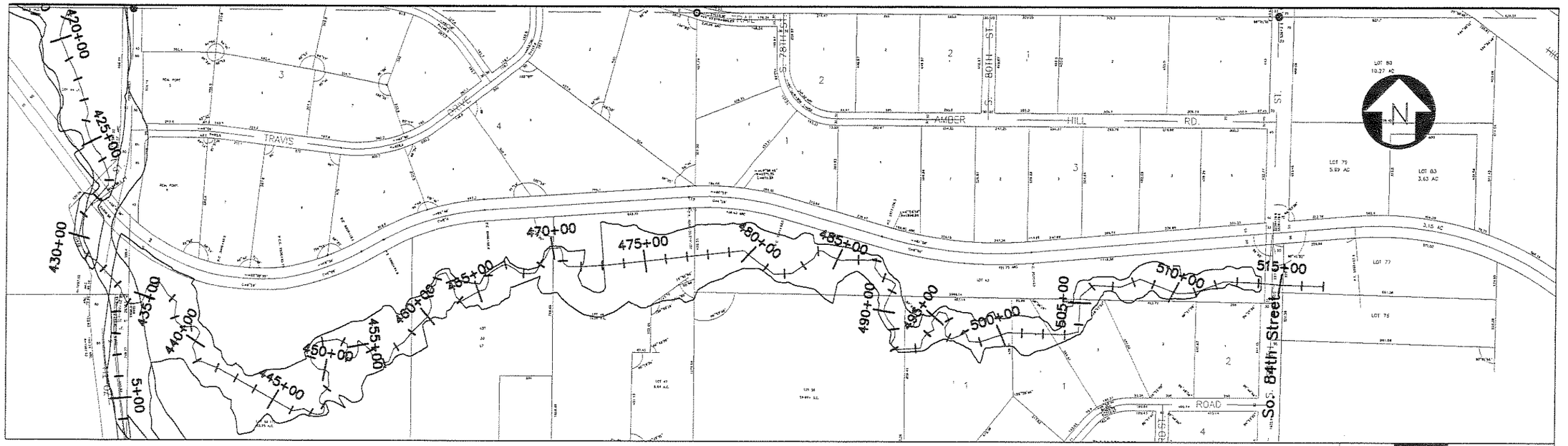


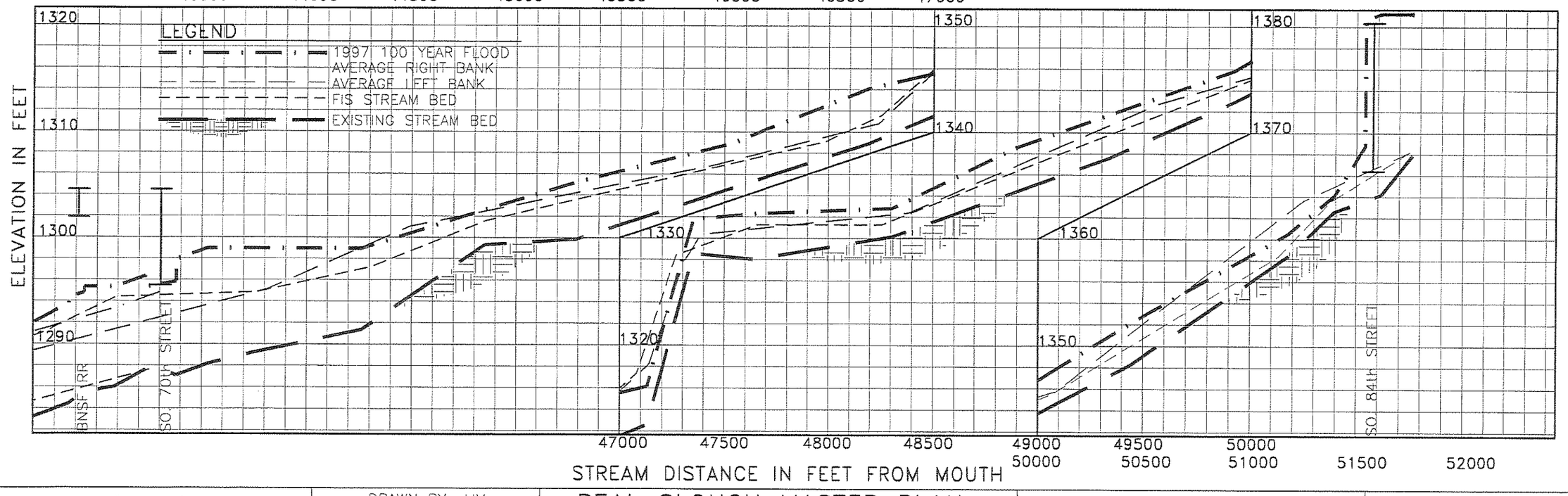
LOCATOR MAP

	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 8 COMPONENTS 70th STREET TO 84th STREET	Figure SG8-PC

6/24/1999 11:28 P.M. FILE: F:\Projects\960280\dwg\IPSHEET8adj.dwg SCALE: 1

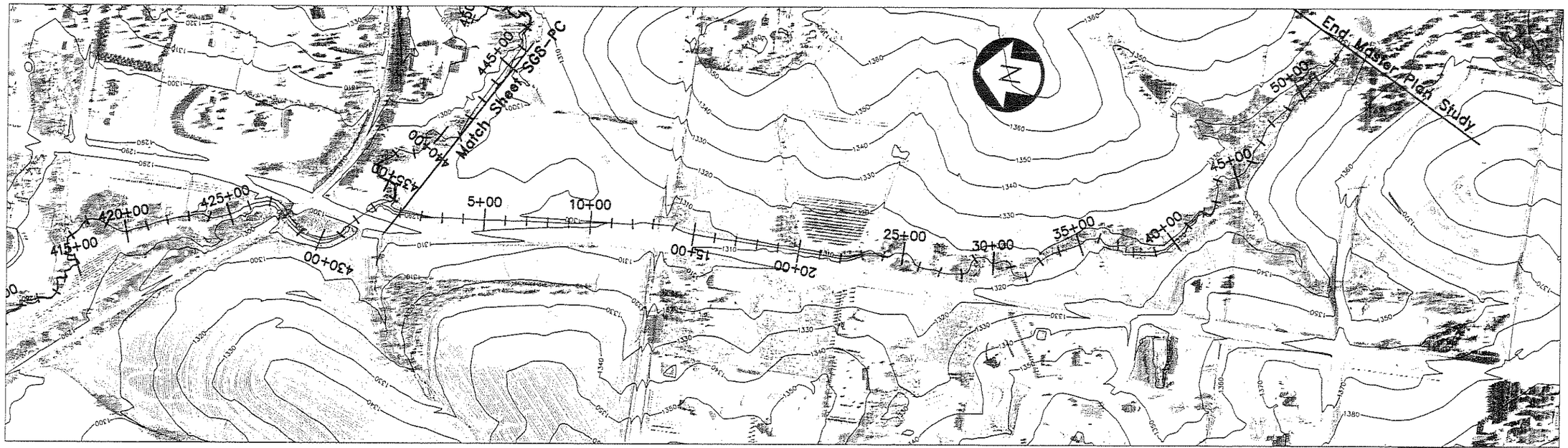
Note: See Figure IV-1, Sheets 1 through 11 found in Appendix B for Comparison of 1997 and FIS Flood Limits.





SCALE: 1" = 500' HORIZONTAL 1" = 10' VERTICAL	DRAWN BY: JJM DATE: JUNE 1999 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 8 PLAN & PROFILE 70TH STREET TO 84TH STREET	FIGURE SG8-FP

5/12/2000 10:12 A.M. FILE: F:\PROJECTS\962280\MSTRPLN\WOS\SHEETBold.dwg SCALE: E: 1



Stream Segment 16 Components

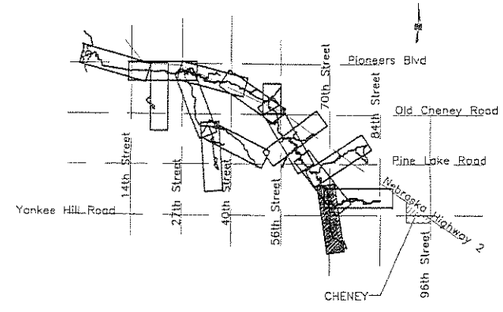
Incorporate one or more stormwater storage facilities that provide target peak flowrate reductions from Sub Areas D & E,
See Figure MP-1, Table MP-1, and Table MP-2

Preserve existing floodplain, riparian vegetation, and natural channel from 0+00 to 52+00

Perpetuate existing functional grade stabilization structure near 52+00 for quality improvement and channel stability

Establish right-of-way from 0+00 to 52+00 for management access

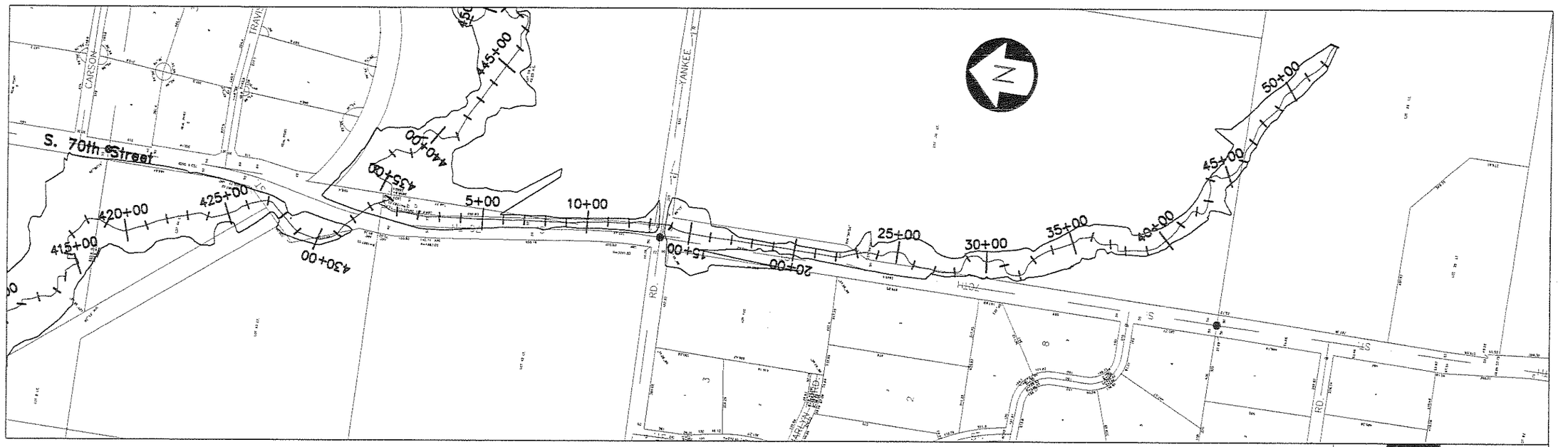
Limit developing subbasin Qp to Master Plan Qp

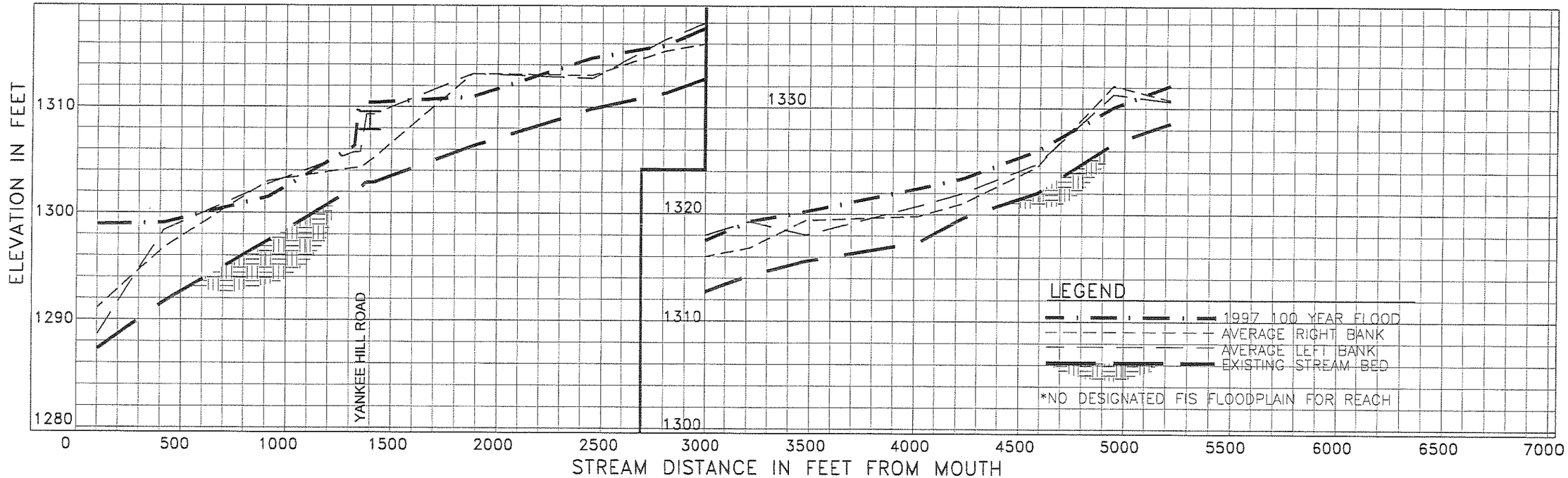


LOCATOR MAP

	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	**STREAM SEGMENT 16 COMPONENTS** **70th STREET TRIBUTARY**	**FIGURE SG9-PC**

6/24/1999 11:07 P.M. FILE: F:\Projects\960280\dwg\TZGSHEET16adj.dwg SCALE: 1





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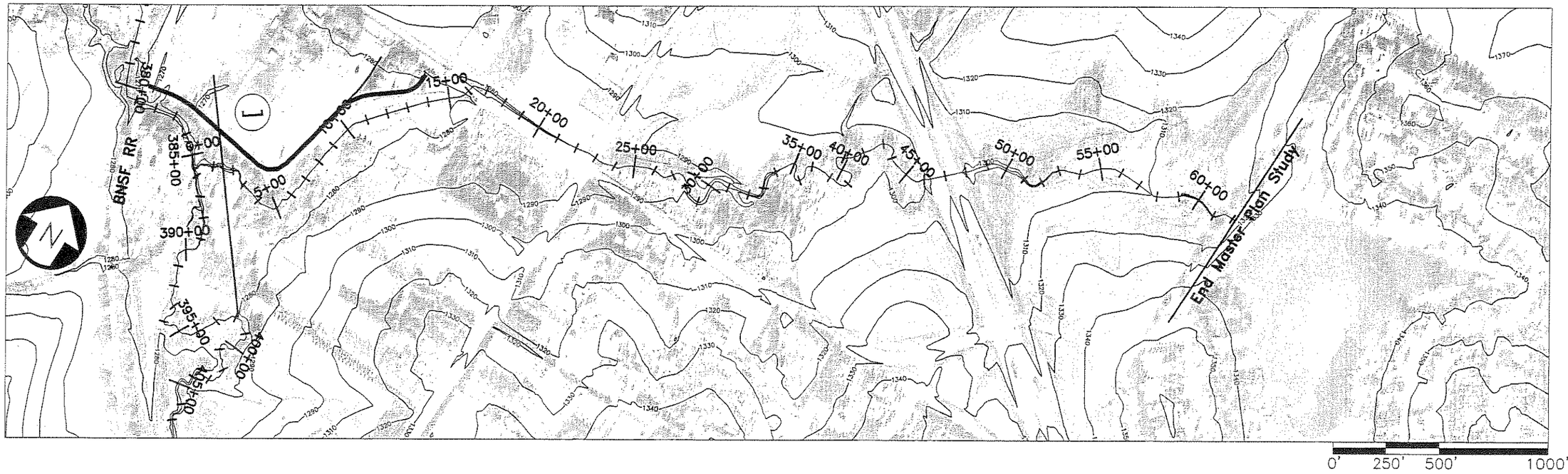
DATE: JUNE 1999
REVISIONS:

BEAL SLOUGH MASTER PLAN
LINCOLN, NEBRASKA

STREAM SEGMENT 16 PLAN & PROFILE
70th STREET TRIBUTARY

FIGURE SG9-FP

5/12/2000 9:49 A.M. FILE: F:\PROJECTS\Beal00\MSTRPLN\MXDS\SHEET16.dwg SCALE: 1



Stream Segment 15 Components

Coordinate training dike construction per sheet SG7-PC

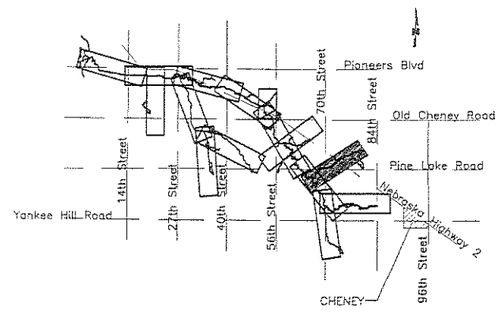
Protect tributary confluence near 41+00

Preserve existing floodplain, riparian vegetation, and natural channel from 0+00 to 62+00

Perpetuate Pine Lake structure above 62+00 for quality improvement and channel stability

Establish right-of-way from 0+00 to 62+00 for management access

Limit developing subbasin Qp to Master Plan Qp



LOCATOR MAP

6/24/1999 11:59 P.M. FILE: F:\Projects\960280\dwg\IZESHEET15adj.dwg SCALE: 1

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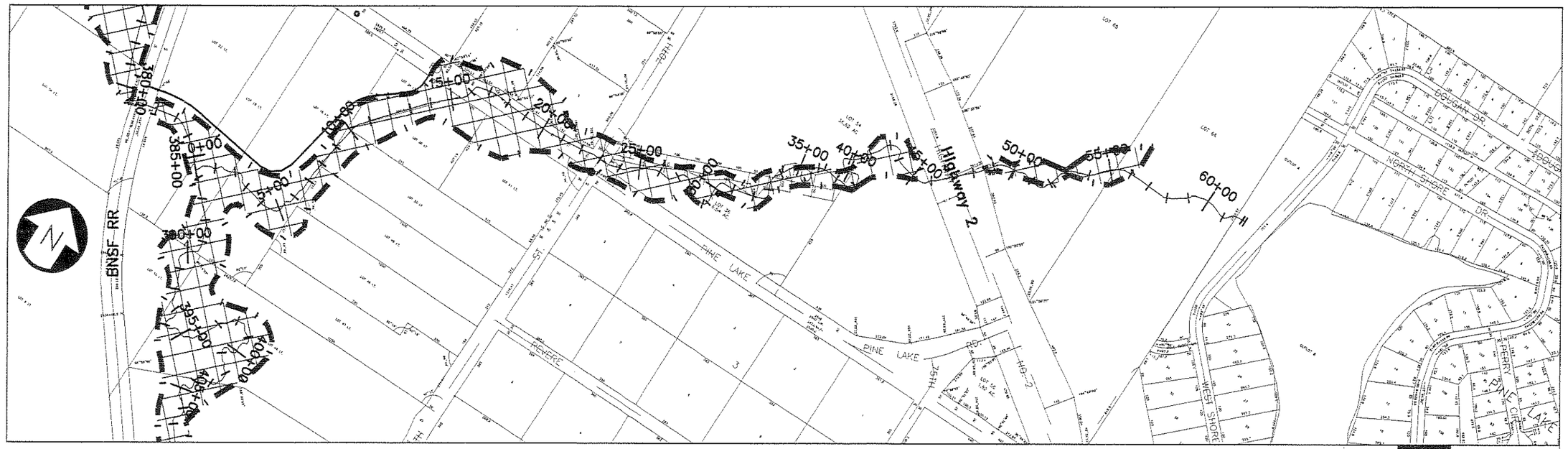
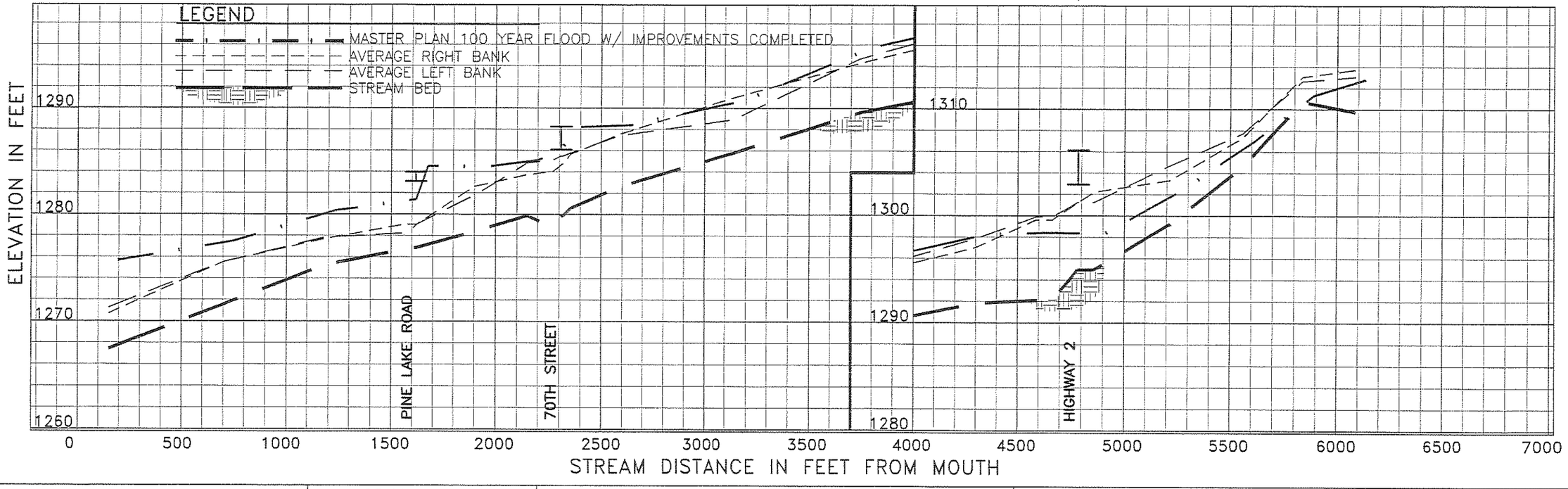


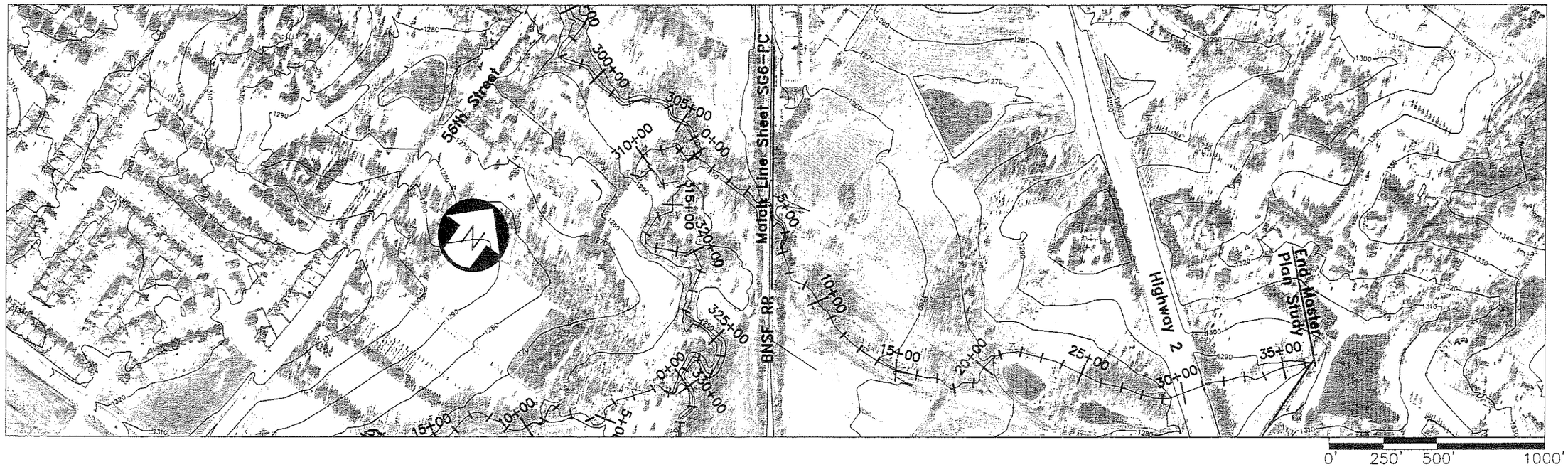
*NOTE: NO FIS DESIGNATED FLOOD PLAIN FOR THIS REACH



6/24/1999 9:44 P.M. FILE: F:\Projects\960280\dwg\ZDSHEET15.dwg SCALE: E: 1

	DRAWN BY: JJM DATE: JUNE 1999 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	**STREAM SEGMENT 15 PLAN VIEW** **PINE LAKE TRIBUTARY**

FIGURE SG10–FP



Stream Segment 14 Components

Incorporate stormwater storage volume into development or redevelopment that provides target reductions in peak discharges from these subbasins

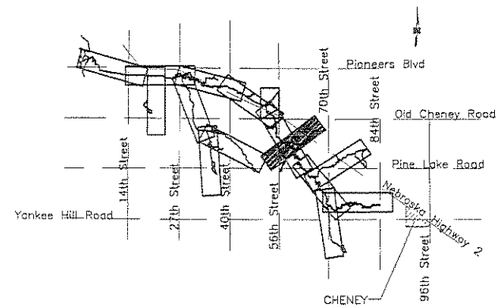
Maintain existing ponds for water quality and channel stability

Establish floodplain, preserve riparian vegetation and natural channel character from 0+00 to 5+00

Establish floodplain, stabilize channel during development construction, re-establish natural channel character from 5+00 to 36+00

Establish right-of-way from 0+00 to 36+00 for management access

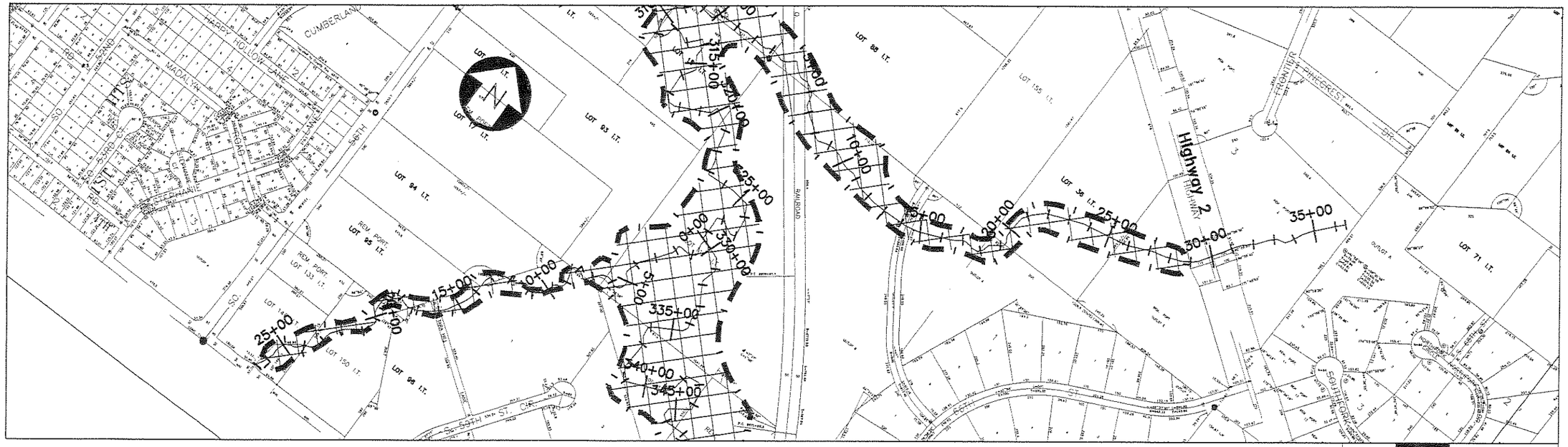
Limit developing subbasin Qp to Master Plan Qp



LOCATOR MAP

	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 14 COMPONENTS HIGHWAY 2 TO 56th STREET TRIBUTARY	FIGURE SG11-PC

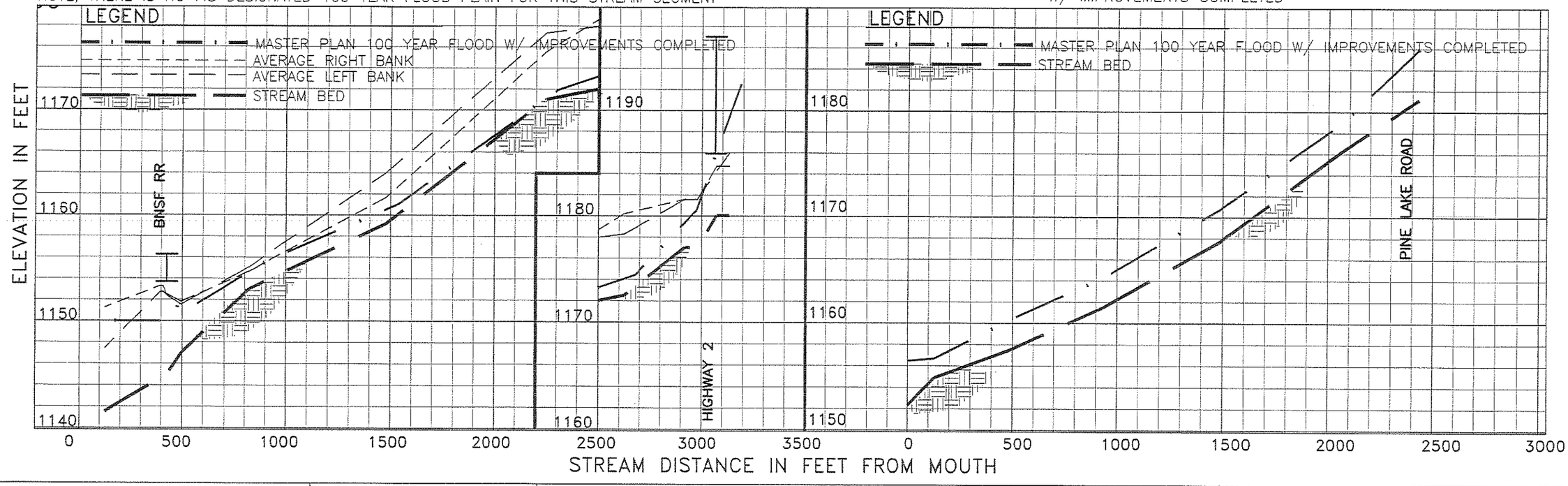
6/24/1999 11:01 P.M. FILE: F:\Projects\960260\dwg\IZCSHEET11adj.dwg SCALE: 10



MASTER PLAN 100 YEAR FLOOD W/ IMPROVEMENTS COMPLETED

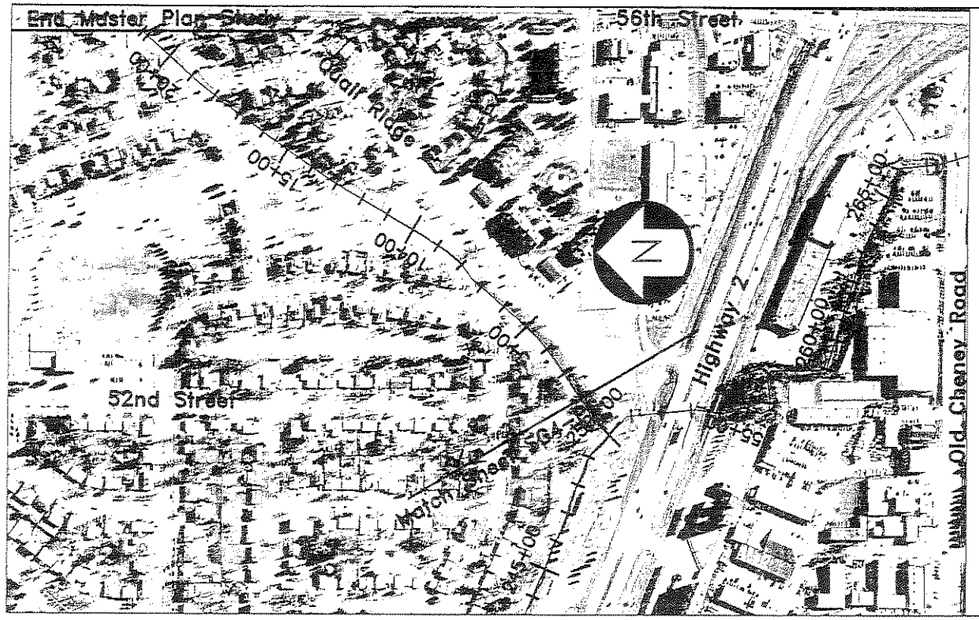
0' 250' 500' 1000'

*NOTE; THERE IS NO FIS DESIGNATED 100 YEAR FLOOD PLAIN FOR THIS STREAM SEGMENT



	DRAWN BY: JJM DATE: JUNE 1999 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	**STREAM SEGMENT 14 PLAN AND PROFILE HIGHWAY 2 SW TO 56th STREET TRIBUTARIES**	**FIGURE SG11-FP**

6/25/1999 11:53 A.M. FILE: F:\Projects\960280\dwg\dwg\TZBSHEET14.dwg SCALE: 1



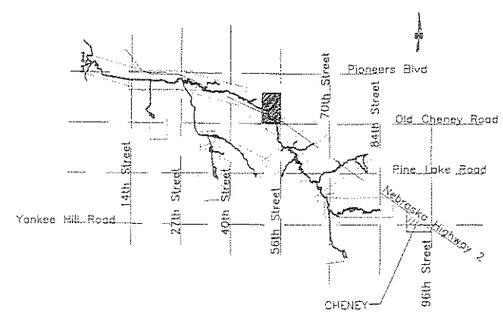
0' 250' 500' 1000'

Stream Segment 13 Components

Remove failing concrete channel liner, construct channel stability improvements from 0+00 to 5+00 and reestablish riparian vegetation See Figure SG3-CD3

Establish floodplain from 0+00 to 21+00

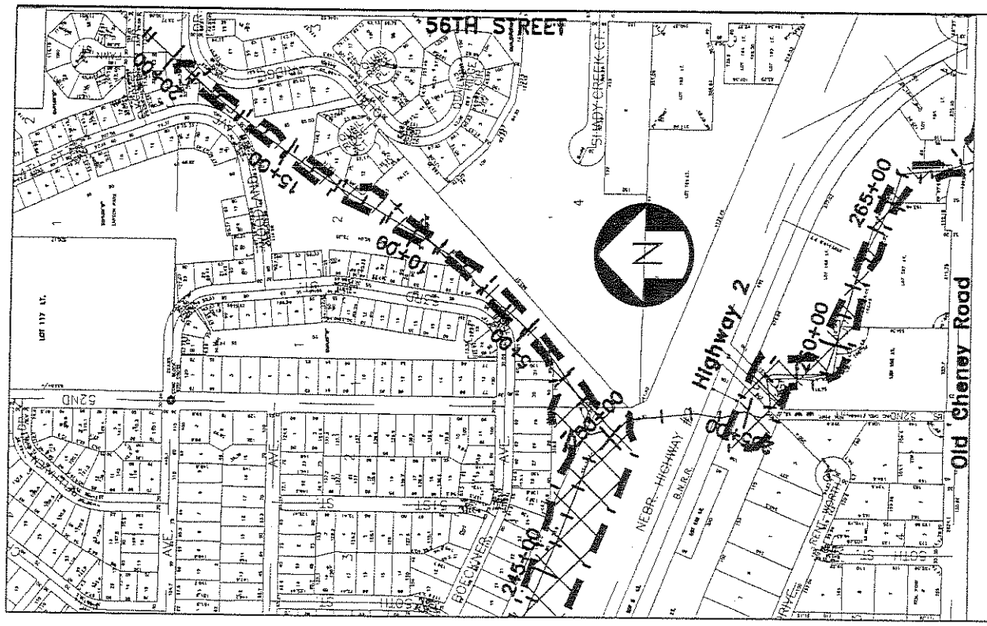
Establish right-of-way from 0+00 to 21+00 for management access



LOCATOR MAP

6/24/1999 10:45 P.M. FILE: F:\Projects\960280\dwg\TASHEET13adj.dwg SCALE: 10

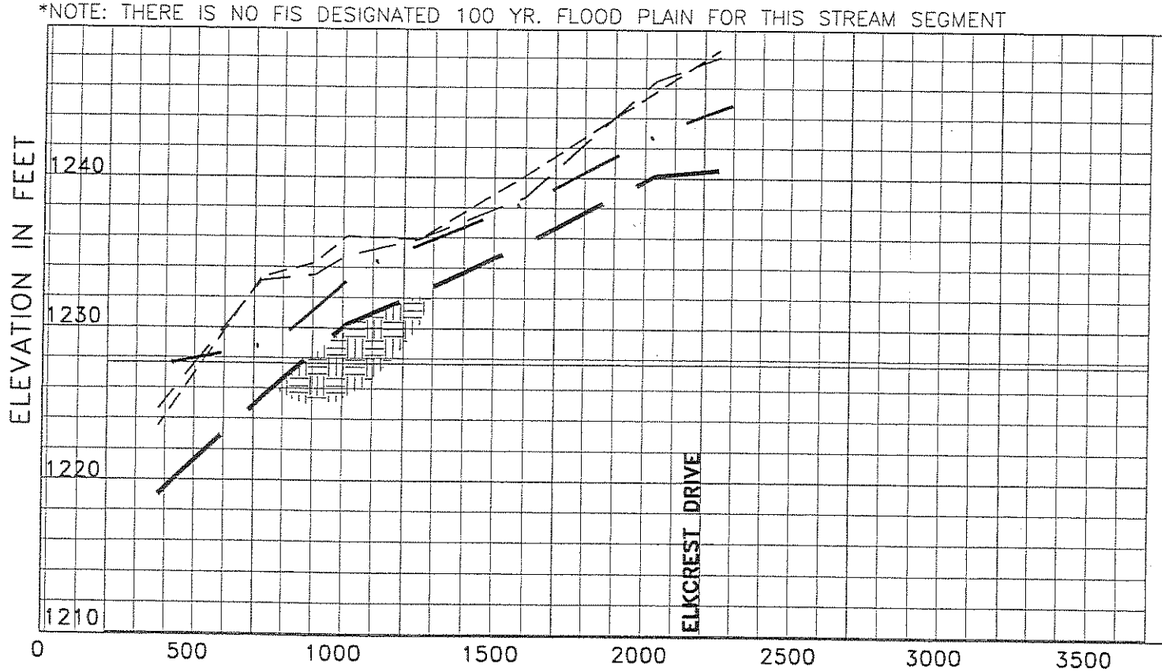
	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 13 COMPONENTS HIGHWAY 2 TO 56th STREET TRIBUTARY	FIGURE SG12-PC



MASTER PLAN 100 YEAR FLOOD

0' 250' 500' 1000'

*NOTE: THERE IS NO FIS DESIGNATED 100 YR. FLOOD PLAIN FOR THIS STREAM SEGMENT



LEGEND

- MASTER PLAN 100 YEAR FLOOD W/ IMPROVEMENTS COMPLETED
- AVERAGE RIGHT BANK
- AVERAGE LEFT BANK
- STREAM BED

6/24/1999 9:29 P.M. FILE: F:\Projects\960280\dwg\dwg\12AASHEET13.dwg SCALE: 1

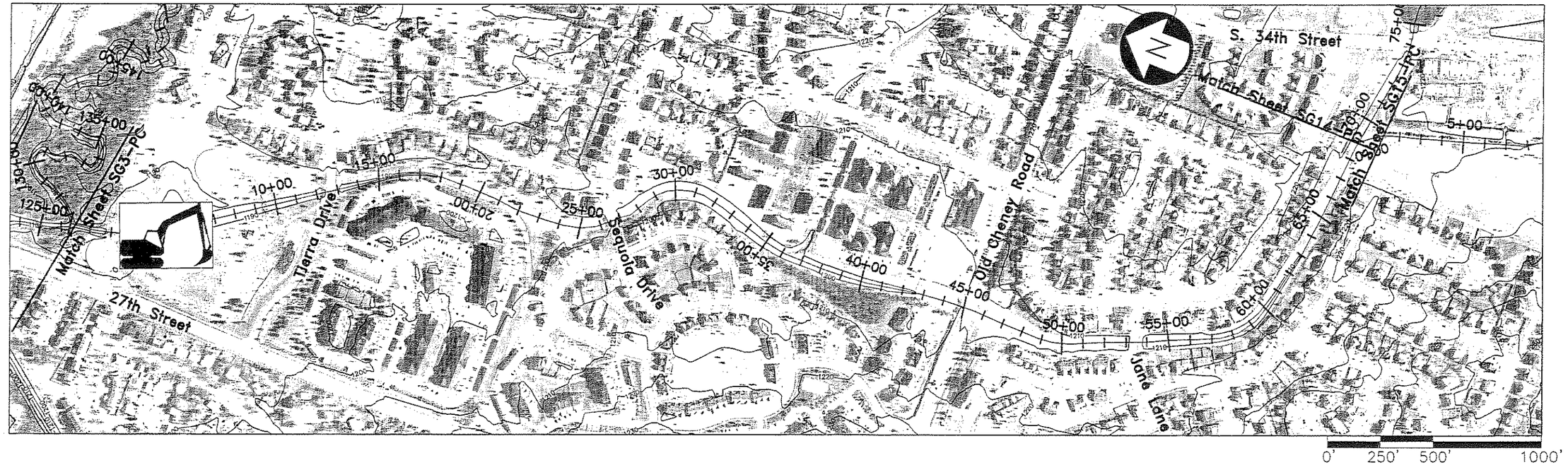
DRAWN BY: JJM
DATE: JUNE 1999
REVISIONS:

BEAL SLOUGH MASTER PLAN

LINCOLN, NEBRASKA

STREAM SEGMENT 13 PLAN AND PROFILE
HIGHWAY 2, NE TO 56th STREET TRIBUTARY

FIGURE SG12-FP



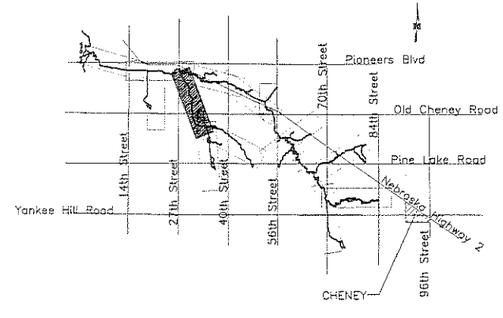
Stream Segment 9 Components

Channel stability improvement from 0+00 to 3+00 with grade check near 1+00

Encourage conversion of houses from walkout to daylight basements along Channel Drive from 25+00 to 29+00

Establish floodplain from 0+00 to 69+00

Establish government access right-of-way from 0+00 to 69+00

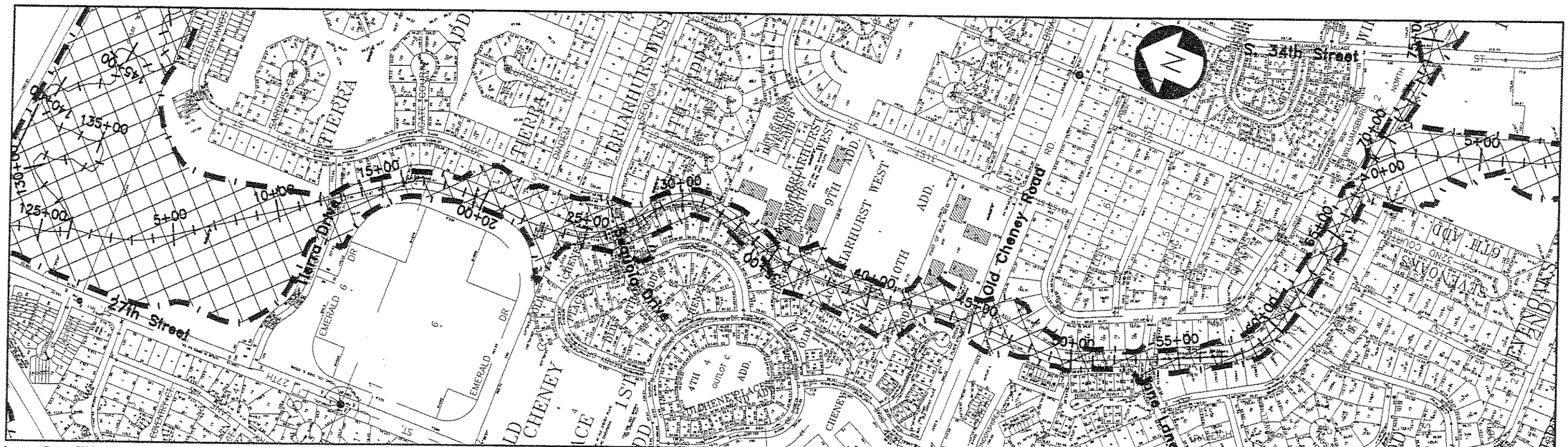


LOCATOR MAP

	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 9 – TIERRA BRANCH BEAL SLOUGH TO 34th STREET

FIGURE SG13–PC

6/24/1999 11:41 P.M. FILE: F:\Projects\960280\dwg\1FSHEET9adj.dwg SCALE: E: 1

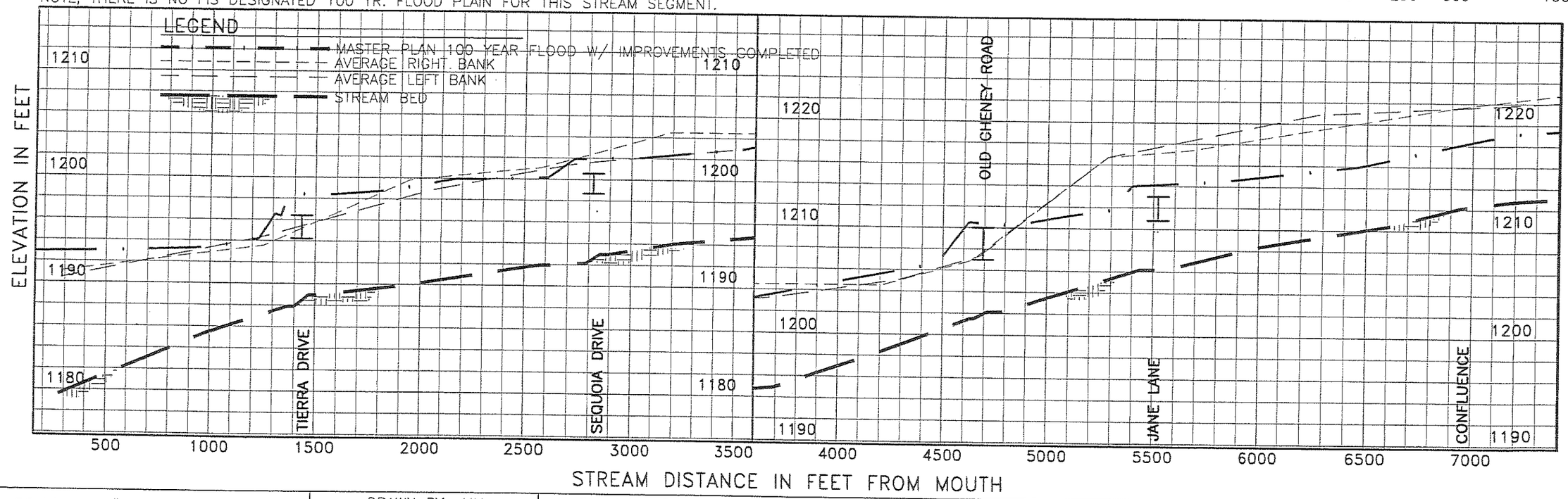


Note: See Figure IV-1, Sheets 1 through 11 found in Appendix B for Comparison of 1997 and FIS Flood Limits.

*NOTE; THERE IS NO FIS DESIGNATED 100 YR. FLOOD PLAIN FOR THIS STREAM SEGMENT.

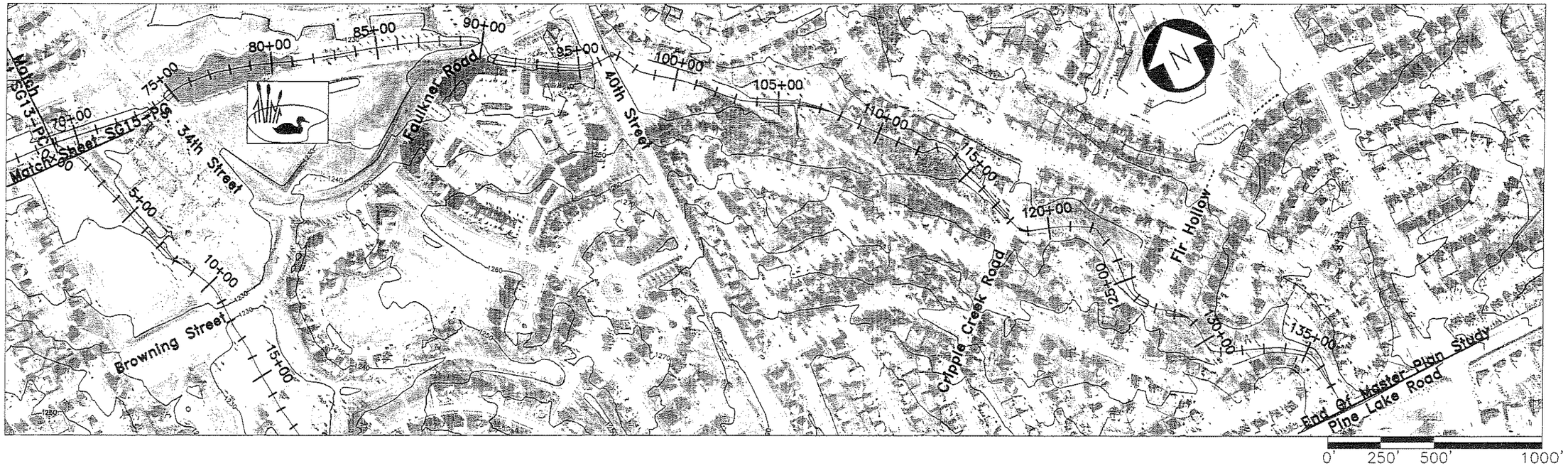
MASTER PLAN 100 YEAR FLOOD

0' 250' 500' 1000'



SCALE: 1" = 500' HORIZONTAL 1" = 10' VERTICAL	DRAWN BY: JJM DATE: 05/20/99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 9 PLAN & PROFILE TIERRA BRANCH–BEAL SLOUGH TO 34TH ST.	FIGURE SG13–FP

6/24/1999 9:11 P.M. FILE: F:\Projects\960280\dwg\10SHEET9.dwg SCALE: E: 1



Stream Segment 11 Components

Perpetuate existing detention pond near 75+00 for water quantity and quality management

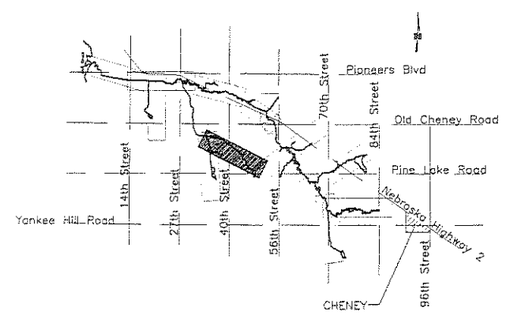
Establish floodplain from 69+00 to 97+00

Establish floodplain and preserve riparian vegetation, and natural channel from 97+00 to 115+00

Establish floodplain from 115+00 to 139+00

Construct water quality wetland near 85+00
See FIGURE SG2-CD2

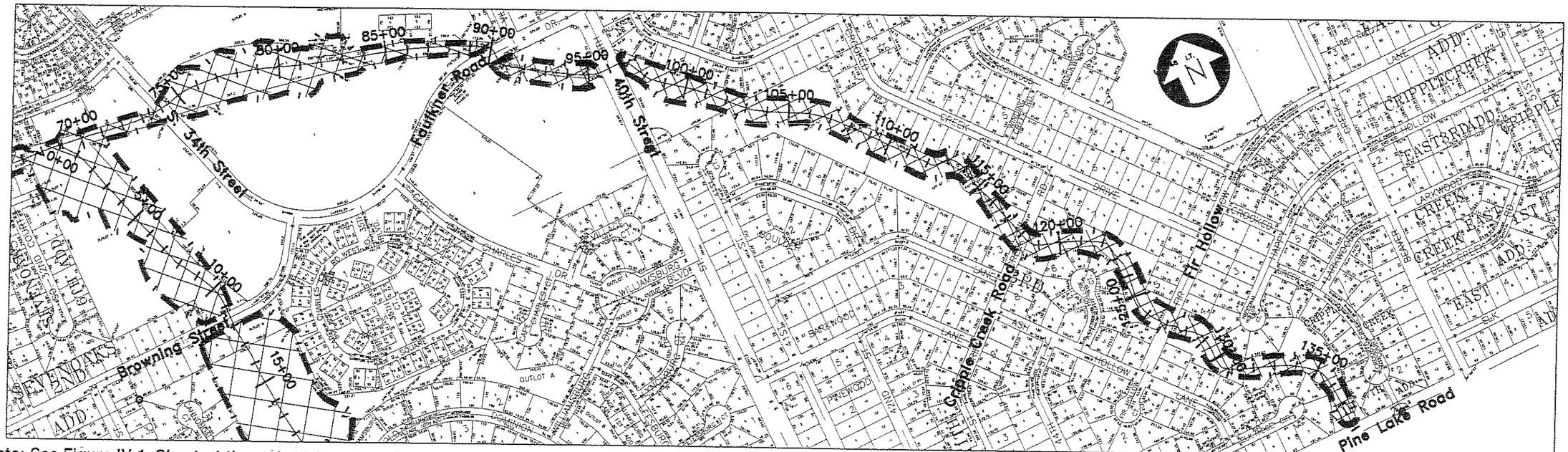
Establish right-of-way from 69+00 to 139+00 for management access



LOCATOR MAP

6/24/1999 10:24 P.M. FILE: F:\Projects\960280\dwg\1VSHEET11adj.dwg SCALE: E: 1

	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	**STREAM SEGMENT 11 COMPONENTS TIERRA BRANCH**	**FIGURE SG14-PC**

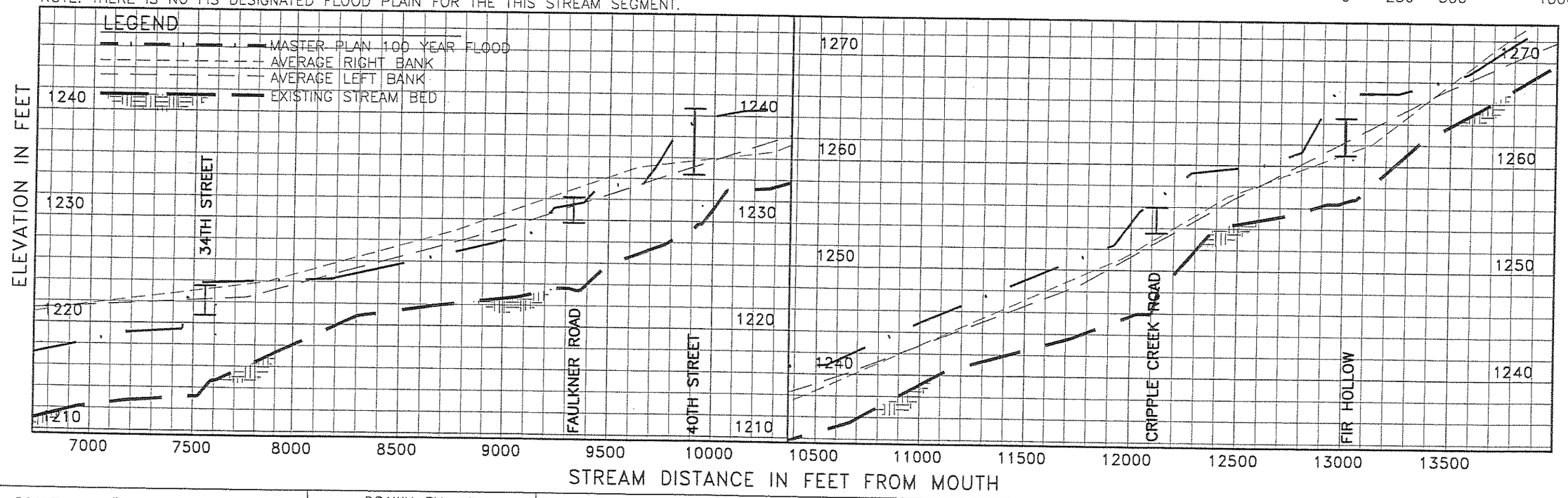


Note: See Figure IV-1, Sheets 1 through 11 found in Appendix B for Comparison of 1997 and FIS Flood Limits.

*NOTE: THERE IS NO FIS DESIGNATED FLOOD PLAIN FOR THE THIS STREAM SEGMENT.

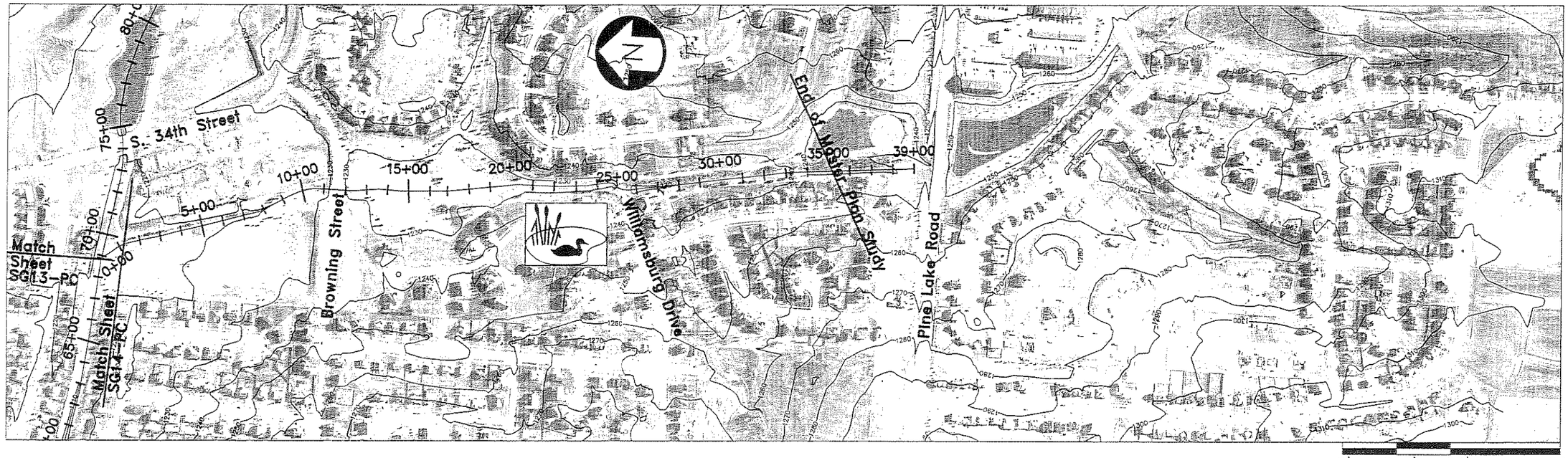
MASTER PLAN 100 YEAR FLOOD

0' 250' 500' 1000'



SCALE: 1" = 500' HORIZONTAL 1" = 10' VERTICAL	DRAWN BY: JJM DATE: 05/20/99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 11 PLAN & PROFILE TIERRA BRANCH–34TH ST. TO PINE LAKE RD	FIGURE SG14–FP

6/28/1999 9:35 A.M. FILE: F:\Projects\960280\dwg\USHEET11.dwg SCALE: E: 1



Stream Segment 10 Components

Perpetuate existing detention ponds near 12+00 for water quantity and quality management

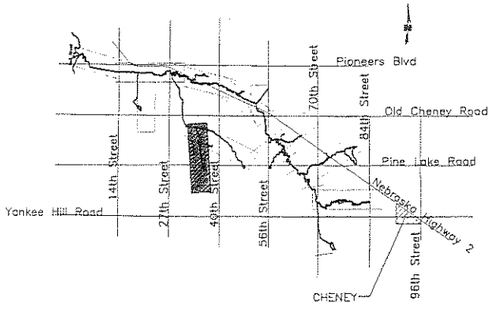
Protect tributary confluence near 16+00, 26+00

Establish floodplain from 0+00 to 39+00, reestablish riparian vegetation from 0+00 to 11+00

Maintain existing detention pond near 34+00 for water quantity management

Construct water quality wetland at existing detention pond near 23+00
See FIGURE SG2-CD2

Establish right-of-way from 0+00 to 39+00 for management access

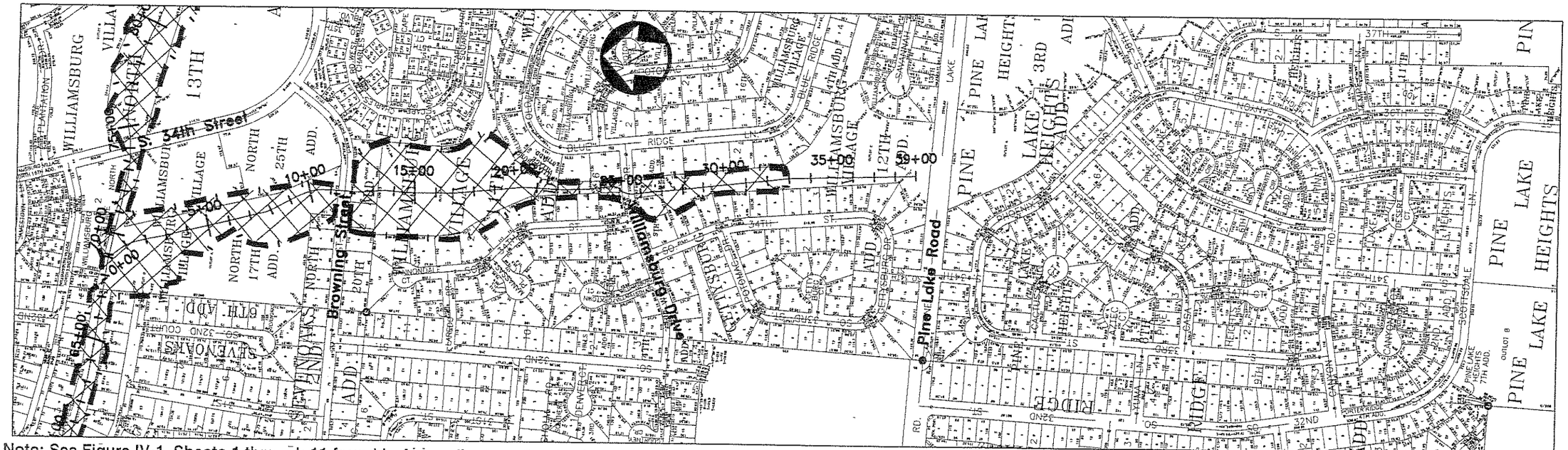


LOCATOR MAP

	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	**STREAM SEGMENT 10 COMPONENTS TRIBUTARY TO TIERRA BRANCH**

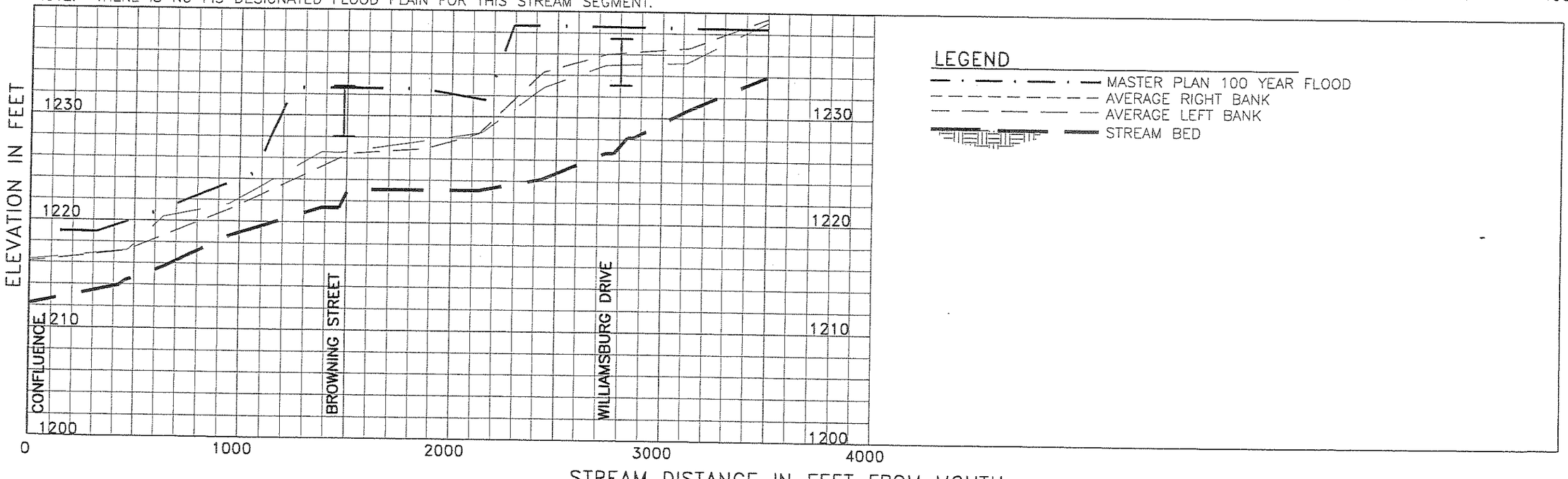
FIGURE SG15-PC

6/24/1999 11:26 P.M. FILE: F:\Projects\960280\dwg\ITSHEET1Dadj.dwg SCALE: E: 1



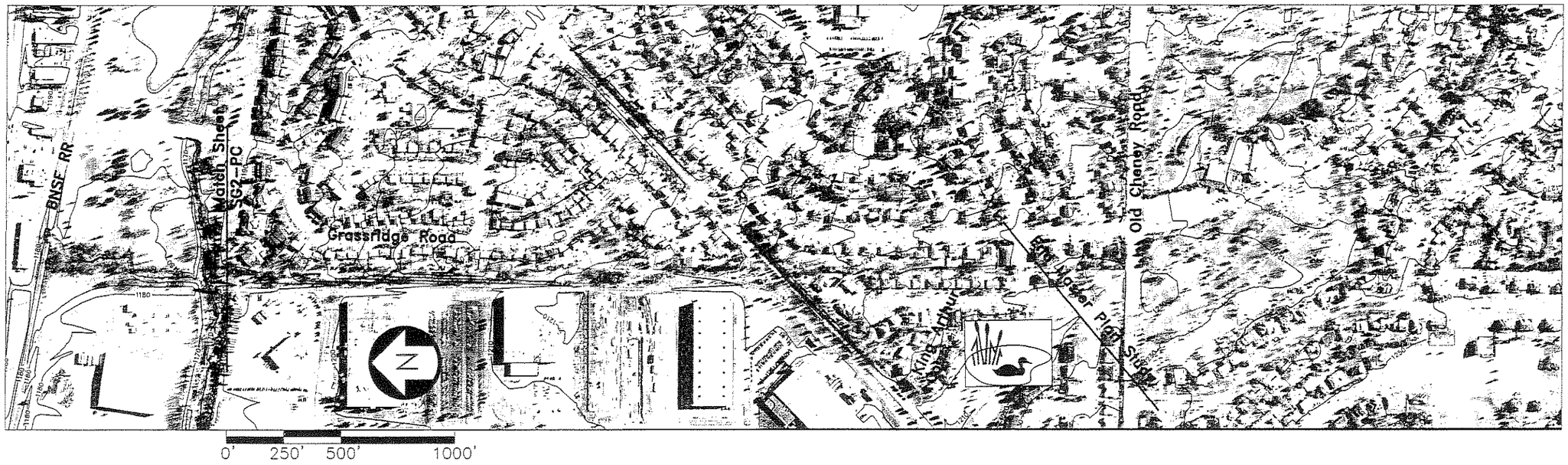
Note: See Figure IV-1, Sheets 1 through 11 found in Appendix B for Comparison of 1997 and FIS Flood Limits.

*NOTE: THERE IS NO FIS DESIGNATED FLOOD PLAIN FOR THIS STREAM SEGMENT.



SCALE: 1" = 500' HORIZONTAL 1" = 10' VERTICAL	DRAWN BY: JJM DATE: JUNE 1999 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 10 PLAN & PROFILE TRIBUTARY TO TIERRA BRANCH	FIGURE SG15-FP

6/28/1999 11:24 A.M. FILE: F:\Projects\960280\dwg\1SSHEET10.dwg SCALE: 1: 1



Stream Segment 12 Components

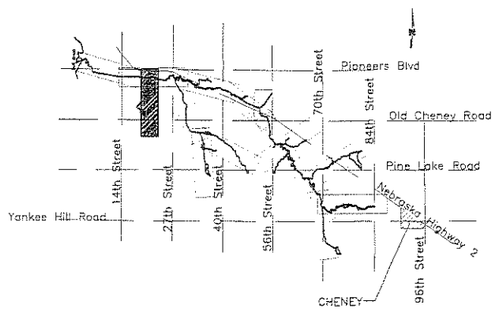
Establish floodplain and preserve riparian vegetation from 0+00 to 37+00

Perpetuate existing detention pond near 38+00 for water quantity management

Construct water quality wetland in park near 44+00 See FIGURE SG2-CD2

Establish floodplain from 40+00 to 46+00

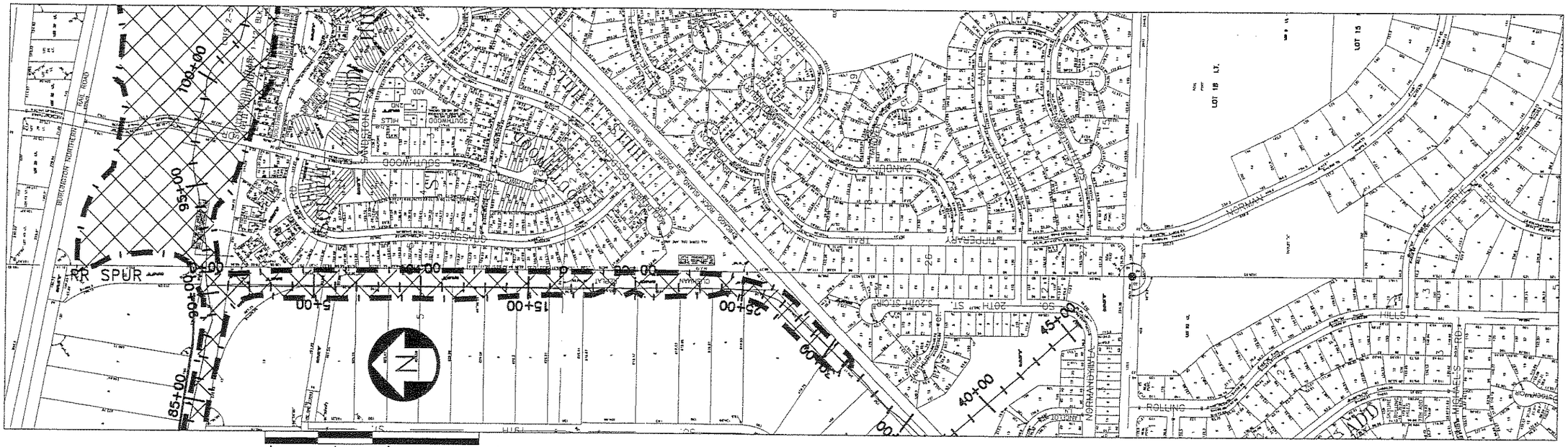
Establish right-of-way from 0+00 to 46+00 for management access



LOCATOR MAP

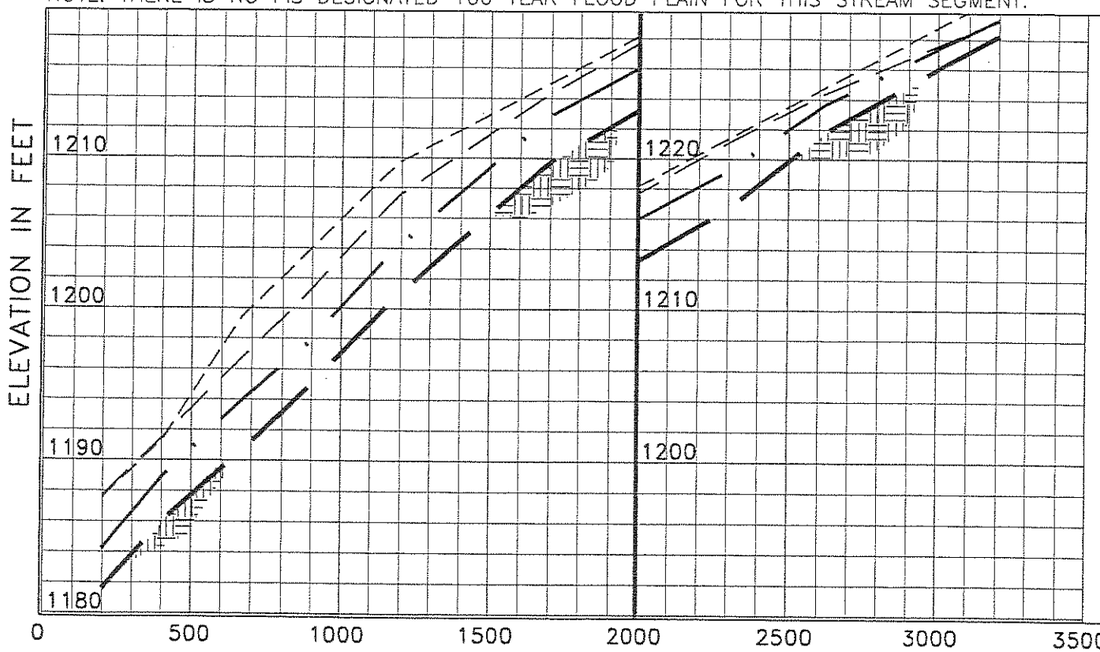
	DRAWN BY: JJM DATE: JUNE 99 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	STREAM SEGMENT 12 COMPONENTS KING ARTHUR COURT TRIBUTARY	FIGURE SG16-PC

6/24/1999 11:17 P.M. FILE: F:\Projects\960280\dwg\11YSHEET12adj.dwg SCALE: 1



MASTER PLAN 100 YEAR FLOOD W/ IMPROVEMENTS COMPLETED

*NOTE: THERE IS NO FIS DESIGNATED 100 YEAR FLOOD PLAIN FOR THIS STREAM SEGMENT.



LEGEND

- MASTER PLAN 100 YEAR FLOOD W/ IMPROVEMENTS COMPLETED
- AVERAGE RIGHT BANK
- AVERAGE LEFT BANK
- STREAM BED

	DRAWN BY: JJM DATE: JUNE 1999 REVISIONS:	BEAL SLOUGH MASTER PLAN LINCOLN, NEBRASKA	**STREAM SEGMENT 12 PLAN & PROFILE KING ARTHUR COURT TRIBUTARY**	**FIGURE SG16-FP**

6/28/1999 7:39 A.M. FILE: F:\Projects\960280\dwg\XSHEET12.dwg SCALE: 1